Universitatea Politehnica Timișoara
Politehnica University of Timișoara

HABILITATION THESIS

TEZĂ DE ABILITARE

Strategies, Modelling and Information Technologies for Sustainable Development

Research field / Domeniul
Engineering and Management / Inginerie și Management

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Contents

A. REZUMAT

A1. Rezumat în limba română

Activitatea de cercetare și profesia de cadru didactic se completează reciproc reușind să ofere cele mai fructuoase rezultate care sunt utilizate în cadrul orelor didactice, dar și în avansarea domeniului de cercetare vizat. Activitatea de cercetare, prin excelență, dezvoltă și fundamentează o serie de competențe și colaborări care contribuie la îmbunătăţirea materialelor didactice și dezvoltarea unor teme de cercetare naţionale și internaţionale.

Teza de abilitare reprezintă o sinteză a preocupărilor și activităţii științifice a autoarei care au fost desfăşurate în perioada ulterioară susținerii tezei de doctorat, din anul 2013. Teza de doctorat intitulată „Contribuții privind managementul riscului în întreprinderea sustenabilă" a fost realizată sub îndrumarea prof. univ. dr. ing. Monica IZVERCIAN. Teza de abilitare este concentrată, în principal, pe realizările care atestă capacitatea autoarei de a conduce activități de cercetare științifică în domeniul Ingineria și managementul producției, cu aplicații în *Dezvoltare sustenabilă* și *Managementul riscului.*

Prezenta teză de abilitare relevă capacităţile și performanțele didactice și de cercetare ale *candidatei dr.ing. Larisa IVAȘCU*, care în prezent ocupă funcția de conferenţiar universitar în statul de funcțiuni al Departamentului de Management al Universității Politehnica Timișoara, întreprinse după susţinerea publică a tezei de doctorat și până în prezent.

În cei 7 ani de **activitate didactică** continuă în cadrul aceluiași departament, candidatul și-a dezvoltat și consolidat capacitățile și performanțele didactice, desfășurând toate tipurile de activități: curs, seminar, laborator, proiect, îndrumare la elaborarea unor lucrări de diplomă și disertație etc., urcând scara ierarhică a funcțiilor didactice. A contribuit la dezvoltarea unor lucrări didactice, manuale universitare și îndrumătoare pentru lucrări aplicative, apreciate în domeniul vizat.

Din perspectiva **activităţii administrative și manageriale,** candidata se implică în diferite activități desfășurate la nivelul Facultății de Management în Producție și Transporturi contribuind la dotarea și gestionarea *laboratorului EcosEc*. Acest laborator este rezultatul unor cercetări desfășurate în aria sustenabilității și a managementului riscului, fiind utilizat la discipline de la programele de master și licență.

Prezentarea capacităților și performanţelor obţinute în **activitatea de cercetare** a candidatei ocupă cea mai mare parte a prezentei teze de abilitare. În acest sens, în prima secţiune autoarea prezintă subiectele abordate și rezultatele obţinute ulterior obținerii titlului de doctor, cu trimitere la lista referințelor bibliografice. Acești ani de cercetare au contribuit la publicarea a 93 de lucrări științifice publicate în reviste de prestigiu și la manifestări internaţionale reprezentative pentru domeniul Ingineria și managementul producţiei. În perioada aceasta a fost editorul invitat al unor publicaţii importante, dovedindu-se astfel aprecierea internaţională a rezultatelor obţinute. Întreaga activitate de cercetare însumează peste 173 de articole științifice.

Prima parte a tezei de abilitare prezintă principalele rezultate obținute de autoare în activitatea de cercetare. Această parte este structurată pe cinci direcții importante:

1. Educația pentru dezvoltarea sustenabilă
2. Abordări ale dezvoltării sustenabile în organizații competitive
3. Modele pentru dezvoltarea sustenabilă și tehnologia informației
4. Managementul riscului
5. Strategii organizaționale în contextul economiei circulare

Prima direcție de cercetare prezintă educația pentru dezvoltarea sustenabilă deoarece dezvoltarea și implicarea organizațiilor în implementarea acestui concept începe cu educația indivizilor. Din aceasta perspectivă este prezentat rolul educației în inginerie pentru dezvoltarea sustenabilă. În urma implicării studenților în educația pentru sustenabilitate se impune abordarea educației în contextul colaborării deschise dintre universități și parteneriatele private.

A doua direcție prezentată și cercetată de autoare este cea a diferitelor abordări ale sustenabilității în organizațiile competitive. Sunt prezentate fundamentele dezvoltării conceptului, managementul întreprinderii, cerințele organizaționale pentru dezvoltarea sustenabilă și relația dintre părțile interesate și implicarea organizațională.

A treia direcție prezintă o serie de modele dezvoltate pe baza caracteristicilor și a implicațiilor organizaționale. Implementarea unor modele în cadrul organizațiilor implică și măsurarea eficienței, de aceea această direcție implică și o propunerea a unei abordări pentru măsurarea implicațiilor sustenabilității în industrie în contextul Industriei 4.0.

A patra direcție vizată de preocupările autoarei este cea a managementului riscului. Abordarea organizațională a dezvoltării sustenabile implică evaluarea riscului și tratarea corespunzătoare. Preocupările au vizat abordarea riscului organizațional, implicațiile IT, riscul de oportunitate, dar și relațiile dintre riscurile ocupaționale și educație, inovare și beneficii. Sunt investigate riscurile în diferite domenii de activitate, iar în urma analizării rezultatelor autoarea propune soluții și modele pentru îmbunătățirea situației analizate.

A cincea direcție vizată de activitatea de cercetare este cea a dezvoltării unor strategii organizaționale în contextul eficientizării activităților organizaționale. Preocupările autoarei în această direcție vizează reducerea impactului asupra mediului înconjurător a unor domenii importante. Managementul deșeurilor, schimbările climatice, emisiile de gaze cu efect de seră, îmbunătățirea proceselor pentru producerea unor articole sustenabile și evaluarea oportunităților și provocările economice se înscriu printre cercetările întreprinse. Ca urmare a gestionării unor proiecte de mobilitate, autoarea a întreprins o serie de colaborări cu colegi din China, Pakistan, Hong Kong, Singapore și Thailanda. Evaluarea principiilor economiei circulare în România și China, dar și a implicațiilor părților interesate din China în dezvoltarea sustenabilă reprezintă pilonii de pornire a unei rețele de cercetare. Această grup de cercetare funcționează și a generat o serie de studii care au fost trimise spre publicare către o serie de reviste cu impact crescut.

Rezultatele activității de cercetare și publicare ale candidatei au fost prezentate în cadrul unor manifestări academice și științifice naționale și internaționale, prin articole publicate în reviste sau în volumele de lucrări ale conferințelor. Candidata a publicat peste **173 de articole**

științifice, în întreaga carieră (2010 – 2020). Ulterior susținerii tezei de doctorat a publicat 128 de articole științifice (2013 – prezent).

Distribuția pe categorii a celor 128 de publicaţii prezintă următoarea formă:

- **18 în reviste** indexate în baza de date Web of Science (Clarivate Analytics), dintre care: 1 cu quartila Q1, 8 cu quartila Q2 (zona galbenă), 3 cu quartila Q3 (zona gri);
- **77 la conferințe internaționale** indexate în baza de date Web of Science (Clarivate Analytics);
- 14 în reviste și volume indexate în alte baze de date internaționale (BDI);
- 19 în reviste sau volume neindexate sau în curs de indexare.

De asemenea, candidata este autoarea unei cărți publicate la o editură internațională, a 5 cărți publicate la edituri naționale recunoscute și a 8 materiale didactice inclusiv în format electronic - suport de curs/îndrumare.

A doua parte a tezei de abilitare prezintă perspectivele de dezvoltare. Aceste perspective sunt prezentate pe cele trei direcţii: didactică, de cercetare și administrativă.

Ultima parte a tezei de abilitare este dominată de referințele bibliografice.

A2. Rezumat în limba engleză - Abstract

The research activity and the teaching profession complement each other, managing to offer the most fruitful results that are used in the teaching hours, but also in advancing the targeted research field. The research activity, par excellence, develops and substantiates a series of skills and collaborations that contribute to the improvement of teaching materials and the development of national and international research topics.

The habilitation thesis is a synthesis of the author's concerns and scientific activity that were carried out in the period after the doctoral thesis, in 2013. The doctoral thesis entitled "Contributions on risk management in sustainable enterprise" was conducted under the guidance of prof. univ. dr. eng. Monica IZVERCIAN. The habilitation thesis is mainly focused on the achievements that attest to the author's ability to conduct scientific research activities in the field of Engineering and Production Management, with applications in Sustainable Development and Risk Management.

This habilitation thesis reveals the didactic and research capacities and performances of the candidate *dr.eng. Larisa IVAŞCU,* who currently holds the position of associate professor in the state of functions of the Management Department of the Politehnica University of Timişoara, undertaken after the public defense of her doctoral thesis and until now.

During the 7 years of continuous **teaching activity** within the same department, the candidate developed and consolidated his teaching skills and performances, carrying out all types of activities: course, seminar, laboratory, project, guidance in the elaboration of diploma and dissertation works, et al., climbing the hierarchical ladder of teaching positions. He contributed to the development of didactic works, university textbooks and guides for applied works, appreciated in the targeted field.

From the perspective of **administrative and managerial activity**, the candidate is involved in various activities carried out at the level of the Faculty of Management in Production and Transport, contributing to the endowment and management of the *EcosEc laboratory*. This laboratory is the result of research conducted in the area of sustainability and risk management, being used in disciplines from master's and bachelor's programs.

The presentation of the abilities and performances obtained in the **research activity** of the candidate occupies most of the present habilitation thesis. In this sense, in the first section the author presents the topics approached and the results obtained after obtaining the doctoral degree, with reference to the list of bibliographical references. These years of research have contributed to the publication of 93 scientific papers published in prestigious journals and to international events representative for the field of Engineering and Production Management. During this period she was the guest editor of some important publications, thus proving the international appreciation of the obtained results. The entire research activity totals over 173 scientific articles.

The first part of the habilitation thesis presents the main results obtained by the author in the research activity. This part is structured in five important directions:

1. Education for sustainable development
2. Approaches to sustainable development in competitive organizations
3. Models for sustainable development and information technology
4. Risk management
5. Organizational strategies in the context of the circular economy

The first direction of research presents education for sustainable development because the development and involvement of organizations in the implementation of this concept begins with the education of individuals. From this perspective, the role of engineering education for sustainable development is presented. Following the involvement of students in education for sustainability, it is necessary to approach education in the context of open collaboration between universities and private partnerships.

The second direction presented and researched by the author is that of different approaches to sustainability in competitive organizations. The fundamentals of concept development, enterprise management, organizational requirements for sustainable development and the relationship between stakeholders and organizational involvement are presented.

The third direction presents a series of models developed based on organizational characteristics and implications. Implementing models within organizations also involves measuring efficiency, so this direction also involves proposing an approach to measuring the implications of sustainability in industry in the context of Industry 4.0.

The fourth direction targeted by the author's concerns is that of risk management. The organizational approach to sustainable development involves risk assessment and appropriate treatment. The concerns focused on addressing organizational risk, IT implications, opportunity risk, but also the relationships between occupational risks and education, innovation and benefits. The risks in different fields of activity are investigated, and after analyzing the results, the author proposes solutions and models for improving the analyzed situation.

The fifth direction targeted by the research activity is the development of organizational strategies in the context of streamlining organizational activities. The author's concerns in this direction are aimed at reducing the impact on the environment of some important areas. Waste management, climate change, greenhouse gas emissions, improved processes for the production of sustainable items and the assessment of economic opportunities and challenges are among the research undertaken. Following the management of mobility projects, the author has undertaken a number of collaborations with colleagues from China, Pakistan, Hong Kong, Singapore and Thailand. The evaluation of the principles of the circular economy in Romania and China, but also of the implications of Chinese stakeholders in sustainable development are the starting pillars of a research network. This research group operates and has generated a number of studies that have been submitted for publication to a number of high-impact journals.

The results of the research and publication activity of the candidate were presented in national and international academic and scientific events, through articles published in journals or in the volumes of conference papers. The candidate has published **over 173 scientific articles** throughout her career (2010-2020). After defending his doctoral thesis, **she published 128 scientific articles (2013 - present).**

The distribution by categories of the 128 publications has the following form:

- **18 in journals** indexed in the Web of Science database (Clarivate Analytics), of which: 1 with quartile Q1, 8 with quartile Q2 (yellow area), 3 with quartile Q3 (gray area);
- **77 at international conferences** indexed in the Web of Science database (Clarivate Analytics);
- 14 in journals and volumes indexed in other international databases (BDI);
- 19 in unindexed or indexed journals or volumes.

Also, the candidate is the author of a book published at an international publishing house, 5 books published at recognized national publishing houses and 8 teaching materials including in electronic format - course support / guidance.

The second part of the habilitation thesis presents the development perspectives. These perspectives are presented in the three directions: didactic, research and administrative.

The last part of the habilitation thesis is dominated by bibliographic references.

B. SCIENTIFIC AND PROFESSIONAL ACHIEVEMENTS, CAREER DEVELOPMENT AND DEVELOPMENT PLANS

1. Scientific, professional and academic achievements

1.1. Education for sustainable development

In a dynamic environment, education is the most effective way to form a social and intellectual basis to implement sustainable development requirements. Due to multiple sustainability concerns at national and international level, the need for education for sustainable development continues to grow. Education for Sustainable Development (ESD) is a way to educate young students and build new knowledge to integrate them into business competitiveness.

Sustainability is an ample and complex concept that needs to be fully explored in terms of its dimensions, practices and benefits. In the past, the concept of sustainability referred strictly to environmental issues. In recent years, the economy and society have begun to occupy an important place in implementing sustainable development at an organizational or institutional level. Sustainable development is, therefore, an important step for governments, the business community, academia and citizens (Bebbington et al., 2017). There is a need for global change. Change is learning and knowledge. In this respect, higher education institutions play a key role in this endeavor. The main responsibilities of educational institutions are to transfer knowledge and research, promote good behavior among its community and stakeholders and support lifelong learning (Aslan, and Reigeluth, 2013). Educational institutions have a positive contribution to the development of business and local communities.

Sustainability is designed to contribute to resource efficiency making future generations benefit from the same opportunities as those present. Organizational approaches to sustainability are numerous, but they are often incomplete. Addressing sustainability is a concern for organizations' stakeholders. Universities are the stakeholders of organizations. Individuals, groups, and organizations become interested in an organization when they have a legitimate interest in performance or success (Bebbington et al., 2017). Higher education institutions are the main actors contributing to the formation of future employees (Cortese, 2003). Educational institutions are part of the stakeholder group. International conferences contribute to identifying links between international knowledge and local practice (Bebbington et al., 2017). It is important that universities participate in various international conferences to identify the requirements of the international economic environment and the local environment (Radinger-Peer, and Pflitsch, 2017). Success factors in implementing sustainable development are also identified by stakeholder requirements (Bebbington et al., 2017). Among the stakeholders are universities. They are directly interested in the development of the economic environment, and the economic environment is a direct interest in the dissolution of universities (Corcoran, et al., 2010). Therefore, it can be said that there is a direct link between universities and the business world.

1.1.1. The Role of Engineering Education for Sustainable Development

The part aims on the level of knowledge accumulated by students following the passing of some disciplines related to sustainable development. The implications of organizations for sustainable development are assessed.

Evaluating literature, a series of sustainable development models applied in educational institutions (Radinger-Peer, and Pflitsch, 2017; Draghici et al., 2015; Fischer et al, 2017; Figueiro, and Raufflet, 2015). These include those presented in Table 1.1. It can be noticed that higher education institutions apply tools based on Sustainability Reporting Indicators or the Global Report Initiative. No other methods applied to resource efficiency were identified in these evaluated sources.

Table 1.1. Sustainability assessment tools in higher education

Author(s)	***Description***	***Implications***
(Radinger-Peer, and Pflitsch, 2017; Draghici et al., 2015)	Global Report Initiative (GRI)	Evaluating the indicators provided in the GRI and monitor them
(Fischer et al, 2017)	Quantitative assessment of environmental impact	The methodology has been divided into different areas of activity: management, academia and university campus
(Figueiro, and Raufflet, 2015)	Unit-Based Sustainability Assessment Tool (USAT)	Evaluation based on indicators and continuous monitoring

It can be noticed that the sustainable development is also assessed and reported by the educational institutions, Table 1.2. This is an internationally accessible action by organizations in all areas of activity (Fischer et al, 2017). At national and international level there is an intense involvement of organizations from different fields of activity in the application of sustainable development. Companies apply different tools and methods to streamline their consumption of resources so that the next generations also benefit from the same opportunities (Ralph, and Stubbs, 2014). At the level of organizations, the application of methods for sustainable development is diverse and leads to more efficient production activities (Moraru, and Cioca, 2010; Babut, and Moraru, 2018).

Table 1.2. Sustainability assessment tools in organisations

Author(s)	***Description***	***Implications***
(Ralph, and Stubbs, 2014)	Global Report Initiative (GRI) Design for Environment	Assessment of indicators provided in GRI and control Designing products in accordance with environmental requirements
(Berchin, 2018)	Life cycle management Kaizen, Kanban Cleaner Production Assessments	Evaluation of products from design to customer Reduction of waste and losses in the production process

Author(s)	***Description***	***Implications***
(Ferrer-Balas, 2009)	Resource Efficient and Cleaner Production (RECP) Five S Lean manufacturing	Efficiency of resource consumption Reduction of waste Efficiency of the production process Reduce losses from company processes

It can be noticed that the tools applied by the organizations aim at a series of benefits of sustainable development: clean production, efficiency of activities, time management, globalization of activities, waste management and others (Ferrer-Balas, 2009).

Materials and methods

This research is based on the review of literature and on market research conducted between 2015 and 2018. Specialized literature research has been undertaken to identify elements that contribute to increasing the level of knowledge and sustainability models applied in educational institutions and organizations, based on the empirical research of the author. This research highlights the importance of sustainable development. For market research, the questionnaire survey was used (Rada, and Cioca, 2017). The questionnaire was applied to students from the master cycle, structured in two directions: knowing the implications of sustainable development (1) and assessing the impact of sustainable development for organizations (2). Questions about (1) were addressed during the first session, and questions about (2) at the end of the sessions. Respondents are students at the Faculty of Management in Production and Transport of the Politehnica University of Timisoara, Romania. There are two disciplines in the curriculum that cover the concept of sustainable development. These disciplines are "Sustainability and Risk" and "Sustainable Development Applied in Logistics Systems". The disciplines are covered in year 2, semester 1 of the master program. Masters students passing these two disciplines account for about 90 students. Of these, 70 respondents were selected who met the following conditions:

- They are employed by companies in the Western Region of Romania;
- They have been employed in the last three months the company;
- They are involved in the activities of their company processes;
- Their participation in courses and seminars is at least 80%;
- They are engineers as a result of the bachelor's degree.

The questionnaire was applied every year at the beginning and end of the courses. The questionnaire survey was applied face to face. At the end of the evaluation of the results, a series of predictions are made using linear regression.

The importance of education for sustainable development: discussion and results

The questionnaire is structured in two directions. This questionnaire was applied to students from the master cycle at the two disciplines covered. The answers are presented in Table 1.3. The questions relate to the definition, implications and activities that contribute to sustainable development. At this stage, questions were raised regarding the knowledge of the concept and

identifying how respondents applied SD practices, Table 1.3. The students are becoming more familiar with the term of SD. In 2015, 20 of the 70 respondents knew the SD concept, while in 2018 their number increased by 50%. This is due to the different actions launched on social environments and companies' activities. Environments and companies' activities aimed at reducing environmental pollution and increasing the living conditions of the population.

By evaluating the implications of the SD concept at work, it can be noticed that respondents who managed to identify components of SD at the workplace are known to be quite small. In 2015, less than 10% of those who identified workplace SD activities were registered. In 2018, 25% of respondents identified activities aimed at sustainably developing the company. The appointment of an effective tool for sustainable development was possible for a few respondents. Only 3 respondents could identify a method or tool. In 2017, the number of instruments identified is well above the level of 2015. In the years 2016-2017 there is an increase in knowledge about SD implications. Among the most frequently encountered tools of the respondents are: lean manufacturing, product life cycle assessment, Resource Efficient and Cleaner Production (RECP), and corporate social responsibility. Applying actions to day-to-day activities refers to: reducing the level of document printing, using bicycles for transportation at work and faculty, and selective collection of waste. As with resource sharing activity, 80% of the cases were used to use "cloud" support to share documents and avoid printing them. From the perspective of the number of benefits that SD can bring, it can be noticed that respondents have identified the five benefits with difficulty. In 2018, there were 13 respondents who identified at least five benefits of SD. By fully evaluating the results obtained before going through courses and seminars related to the sustainability principles, it can be said that the respondents have a gap in this direction. Therefore, learning needs to be strengthened during the bachelor's cycle because students apply at work the basic knowledge acquired during their training.

Table 1.3. Students perception of sustainable development (source: own calculation) - part 1

Dimension of SD	2015	2016	2017	2018
Understanding the concept of sustainable development	20	23	28	31
Meet the concept's implications at work	5	8	13	17
Knowing an instrument for sustainable development	3	5	11	16
Applying actions to reduce resources in everyday life	21	33	38	41
Sharing resources with friends / colleagues / acquaintances	18	21	28	39
Identifying at least five benefits of SD in organizations	2	7	9	13

The next step in the application of the questionnaire was the completion of the Sustainability and Risk courses and Sustainable Development Applied in Logistics Systems. At this stage, we resumed a series of ideas from the initial phase of the questionnaire. These ideas have been

reformulated to reach the market research objective, Table 1.4. The objective of the market research was to assess the level of knowledge accumulation related to SD during one semester and the ability to apply the notions learned at the workplace. At the end of the knowledge transfer period, it can be noticed that the respondents were aware of the importance of SD, with a significant increase in affirmative responses (45 respondents answered in 2015, and in 2018 all respondents answered affirmatively). Therefore, the level of perception of some notions is influenced by the media, social networks, the trend of the business environment, and other elements. In 2018, most companies report their sustainability or are concerned about activities that contribute to the sustainable development of the organization. Implications at work were identified by 68 respondents in 2015 and by all respondents in 2017. All master students knew at least one instrument that contributes to the sustainable development of organizations. Actions on daily activities have begun to intensify. Respondents are involved in activities, such as: proper waste collection, equipping houses with own composting, depositing of electrical, electronic and household equipment in specially arranged places, reducing electricity consumption (switching off when leaving the room), reducing the amount of water (stopping the tap in foaming breaks), adequate lighting in the room, increasing the purchase of natural products, increasing the interest in e-book and others. Starting in 2015, respondents' interest in resource sharing has begun to grow. In 2015, 55 respondents answered affirmatively to resource sharing actions. The number of respondents increased, all respondents were involved in 2018. Sharing actions mainly refer to: sharing your own car on the road to work or college, sharing books and workspace. The benefits of sustainable development are numerous and have been identified in a large number of respondents. Following several lessons at the classroom, there is an ease in identifying the benefits of SD by the respondents. These benefits have been identified: increasing economic efficiency, reducing losses, increasing re-use, recycling and remanufacturing, reducing production time, reducing raw materials, improving communication, improving public image and more.

Table 1.4. Students perception of sustainable development (source: own calculation)-part 2

Dimension of SD	2015	2016	2017	2018
Understanding the concept of sustainable development	45	53	68	70
Meet the concept's implications at work	68	70	69	70
Knowing an instrument for sustainable development	70	70	70	70
Applying actions to reduce resources in everyday life	70	70	70	70
Sharing resources with friends / colleagues / acquaintances	55	63	68	70
Identifying at least five benefits of SD in organizations	50	53	63	69

At the end of the first semester, a series of interactive activities were undertaken to deepen the concept of sustainability and lean. A game that integrates sustainability and lean principles has been developed and used in a workshop. This game was played by the 70 students, being a

gaming-based learning method that helped them to implement and develop strategies for sustainable companies.

Model of increasing student involvement in sustainable development

Lifelong learning is an important attribute in professional competitiveness. At the same time, the early learning of concepts applicable in the economy can contribute to increasing the competitiveness of the business environment (Radomska, 2015).

Using linear regression, Table 1.5 shows the expected results for 2019 and 2020 for initial testing of the level of knowledge of sustainable development. Knowledge initially held by respondents is influenced by the workplace and different methods of promoting new business concerns. The values of R^2 are close to 1, which means that the accuracy of the expected data is high. The equation of regression is presented and it can be seen that the number of respondents that streamline the consumption of resources in daily actions will increase considerably. The concept of sustainable development will be known by more and more master students as a result of the popularization of actions at the level of organizations. Values of p-value is less than 0.05, it can be said that we are 95% confident that there is a real difference between the two stages (the concepts of sustainability education help or help future employees). The p-value is lower, the more confident we are that the alternative hypothesis is true, which in this case means that learning the concepts of sustainability contribute to students as professionals.

Table 1.5. Prospects for students' level of knowledge about sustainable development (source: own calculation)

Dimension of SD	Equation of regression	R^2	p-value
Understanding the concept of sustainable development	$y = 3.8x + 16$	$R^2 = 0.989$	0.00018
Meet the concept's implications at work	$y = 4.2x - 4$	$R^2 = 0.9955$	0.0012
Knowing an instrument for sustainable development	$y = 4.5x - 2.5$	$R^2 = 0.9666$	0.00034
Applying actions to reduce resources in everyday life	$y = 6.5x + 17$	$R^2 = 0.9076$	0.0021
Sharing resources with friends / colleagues / acquaintances	$y = 7x + 9$	$R^2 = 0.9387$	0.00043
Identify at least five benefits of SD in organizations	$y = 3.5x - 1$	$R^2 = 0.9761$	0.0032

Figure 1.1 presents a model for increasing students' implications for sustainable development. In order to increase students' awareness and involvement in sustainable development, the following directions should be accessed: intensifying educational activities, interactive games-based methods, developing a sustainable culture on campuses, and involving students in research. All these activities aimed at increasing students' knowledge have a direct impact (on

organizations, educational institutions and culture) and indirect impact (global economic growth, changing business practices and changing the lifestyle of society).

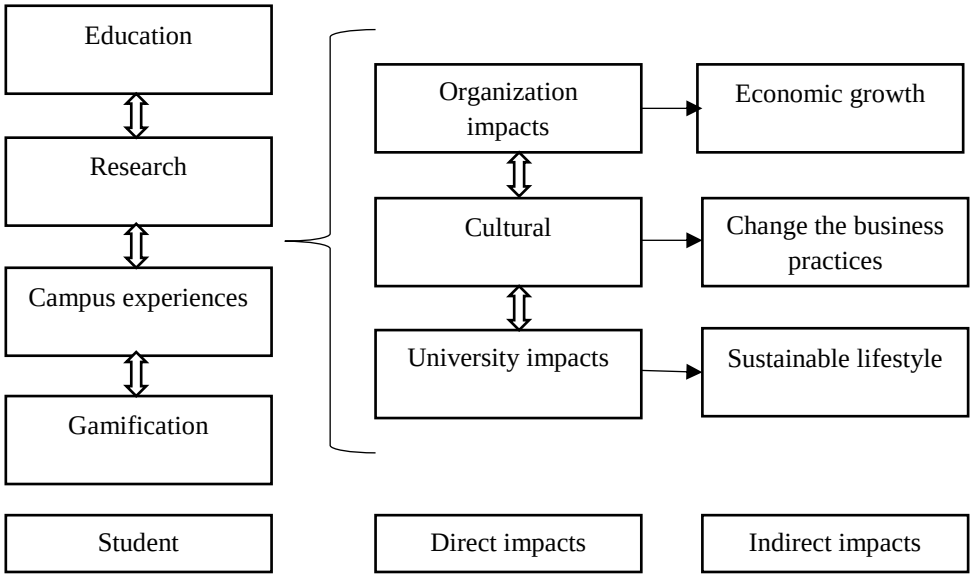


Figure 1.1. Model for raising students' level of knowledge

Compared to other proposed models, this model includes:

- The three categories of implications: student, direct impacts, and indirect impacts.
- For the student, gamification is an attractive learning method. It must be included in learning-teaching methods.
- For the student, family education contributes to the foundation of learning.
- As a direct impact, the culture of the university, to which the student, is part has a major impact.
- As an indirect impact, the sustainable lifestyle is very important for the education for sustainability, because the lifestyle is based on long time.

The aim of this section is to develop a new perspective on the application of the concept of sustainable development in organizations. Sustainability has an important role for organizations, being an approach that most people have accessed. It is a step that helps to increase organizational competitiveness. Increasing organizational competitiveness is supported by learning and knowledge sharing (Starzyńska, et al., 2013; Sukitsch, et al., 2015; Siva, et al., 2016). Involving students in disciplines designed to increase the level of training contributes to improving the economic environment. Sustainable learning must be done during university or masters studies. The results obtained from the two disciplines help to support this idea.

1.1.2. Education for sustainability: public-private partnerships

This section aims to highlight the importance of public-private partnerships for sustainability. Sustainability is an optional approach, but more and more organizations are involved in sustainable development. The tools adopted by organizations for sustainable development have multiple, including ISO standard management and other tools that improve the efficiency of the activities. But education for sustainability needs to be improved. More and more

organizations are interested in collaborating with state institutions to transfer knowledge and improve the knowledge of future employees.

Our planet has reached a population of 7 billion people and its natural resources are limited (often named as scarce). It is becoming increasingly true that the issues of sustainable development, generated by the climate change, are increasingly acute (Asif and Searcy, 2014). Thus, it is not only corrective measures of the generated situations or changes that are generated by a short- and medium-term vision, but especially it is a strong need for changing the way on how we act in a responsible manner (Borella and de Carvalho Borella, 2016). We need to clearly understand that our today actions can have future implications for both people and the planet. In this context, Sustainable Development Education (ESD) is a key factor in changing the way people think and act for a sustainable future.

The strongest voice in the field of sustainable development, UNESCO has clear objectives, actions and measures to improve access to quality education in sustainable development (at all levels and in all social contexts). UNESCO's work in this field is guided by the "Education 2030 Agenda and Framework for Action", where for ESD is mention the specific target of the Sustainable Development Goals (as the SDG4 referring to Education and the connected approaches). UNESCO is responsible for coordinating the Global Action Program (GAP) on ESD, Figure 1.2.

- To facilitate networks and bonds among activists that defend ESD;
- To improve ESD teaching and learning methods and tools;
- To help countries to adopt the Goals of the Millenium by means of ESD;
- Reducing the negative effects on the environment;
- To improve the standard of living of the social environment
- To offer countries new opportunities to adopt ESD in their efforts of educational renewal.

Figure 1.2. Specific goals of ESD, according to UNESCO

Public-private partnerships for sustainable development are present and operate at national and international level. In order to achieve these public-private partnerships, private actors are involved in the development of the different stages of policy development: agenda planning, organizing activities, negotiation, resource allocation, monitoring and execution, and control of results. In achieving these types of collaborations, the success of the implementation is held by the private actors. This fact occurs because in this form of public-private partnerships are hierarchized and dominated by public decision-makers (Aguilar, 2018; Ärlemalm-Hagsér, 2013). Private actors fulfill tasks that public actors cannot fulfill or private actors perform more

effectively. This form of public-private partnerships complements the traditional forms of organizational policies. This approach is more a new form of collaborative governance, less structured and oriented, in which autonomous political actors combine forces on all components of the policy process. With the adoption of the 2030 Agenda for Sustainable Development and the Sustainable Development Goals, public-private partnerships have become even more prominent. The UN agenda is an action plan adopted for actions undertaken at national and international level. The 17 Objectives cover all areas of activity and are not required to be fulfilled all. The 17 goals are operationalized in 169 targets to be achieved by 2030 (Balasoiu et al., 2014; Bascopé et al., 2019).

These goals complement those that have not been achieved so far. These partnerships are becoming more attractive to organizations because they have different benefits. The implications of these partnerships are shown in Figure 1.3. It is observed that these partnerships contribute to accelerating sustainable development and to other additional benefits.

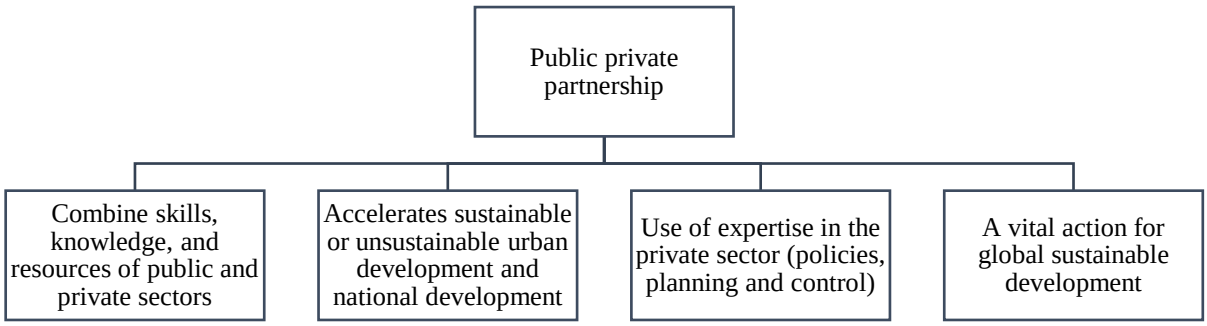


Figure 1.3. The implications of public-private partnerships

Relationship between Education for Sustainable Development and Environmental Education

A terminological and conceptual problem seems to be the relationship between Education for Sustainable Development and Environmental Education. According to the UNESCO Guidelines, ESD is different from the environmental (ecological education named sometime):

- Environmental education is limited to ecology issues and emphasizes on the relationship between man and the natural environment, focusing on conservation issues and how to properly manage resources;
- ESD therefore includes environmental and environmental education. ESD has a wider context that also considers education relative to social and cultural factors and socio-political issues such as equality, poverty and quality of life (Unesco, 2005, p. 46).
- ESD must be addressed to all the dimensions of sustainability: environmental, social and economic.

As supported by (Tormey et al., 2008), ESD facilitates the development of the knowledge, skills and attitudes of people (pupils, students, adults) needed to engage and cope with local and global environmental, economic and social challenges (Bell, 2010; Boyd, 2018). Research has highlighted that systematic, critical, and creative thinking are essential skills that need to be developed to make decisions and logical judgments with respect to the sustainable development values and principles.

Regarding the impact of the sustainability concept at the formal education, there can be considered two levels as depicted in Figure 1.4.

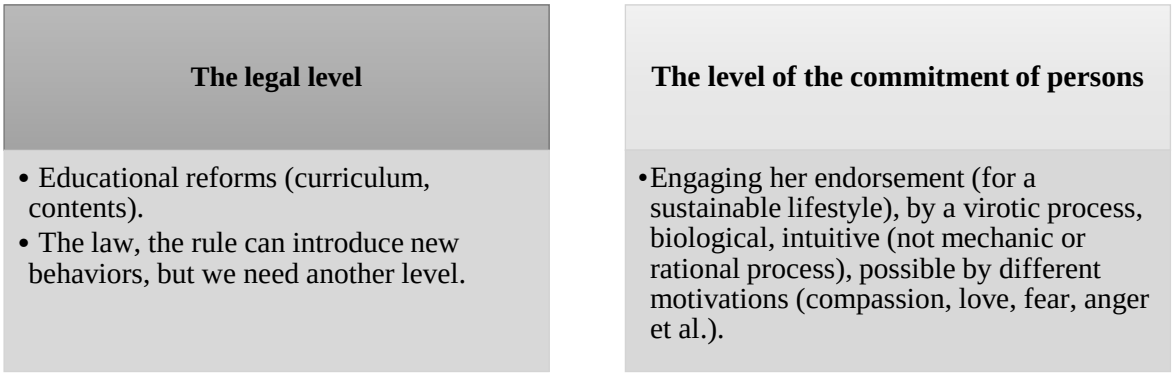


Figure 1.4. Levels of sustainability concept

ESD must be accompanied by a positive perspective and view of the future of mankind and the planet and it should be supported by a broad consensus of the population, including all categories of educators. ESD involves provoking respect for life, caring for the planet and caring for the whole life community (Brundiers and Wiek, 2013). These aspects are closely related to the sharing of fundamental values, as well as the life ethical principles and knowledge in the field of sustainable development (respect for the planet Earth and life in all its diversity, care for the life community with understanding, compassion and love, building democratic societies that are just, participative, sustainable and peaceful) (Babut and Moraru, 2018; Darabont et al., 2017). The ESD should be a focal point for the future of the entire educational system (Gadotti, 2008).

Generally accepted in literature and the community of practitioners and policymakers, ESD focuses on developing and strengthening individual competencies, which facilitates the individual's positive intention, contribution, and active participation in various sustainable development processes (Duhn, 2012; Eernstman and Wals, 2013; Dyment, 2014). It is clear from this definition that all types of skills and competences, including basic skills such as reading, writing, mathematics, are included (Daries et al., 2009; Cutter-Mackenzie and Edwards, 2013; Caiman and Lundegård, 2014; Dawson and Beattie, 2018). Therefore, ESD is about educating for a sustainable lifestyle, being fundamental to sustainable development and creating a more sustainable future for all. In addition. There have been recognized that all sciences can contribute to ESD (Gadotti, 2008):

- Mathematics, physics and chemistry can provide models of approach, determination of environmental abatement, poverty alleviation or how resources are used;

- Linguistics can describe and analyze the role that communication and promotion play in consumption habits;
- History and social sciences can describe in chronological and phenomenological terms ethnic issues and gender inequalities.

In accordance to the above mention consideration of (Gadotti, 2008; Eriksen, 2013; Elliott and Young, 2016) he considered that the most important topics to be taught for ESD are those described in Figure 1.5.

The *new energetic paradigm*	The new economic and social model based on new values, on multiple sources of energy and on the association of small producers instead of a few gigantic energy companies
The *new consumption standards*	-Change energy consumption and distribution habits (saving water, non-use of plastic cups etc.) and change our current habits of consumption in order to reduce wastefulness and irresponsible consumption
Use of renewable sources of energy	To save energy and re-think our lifestyle

Figure 1.5. Topics to be taught for ESD (Gadotti, 2008)

In terms of the *level of education*, there must be adopted different strategies for the ESD (Gadotti, 2008) as they are depicted in Figure 1.6.

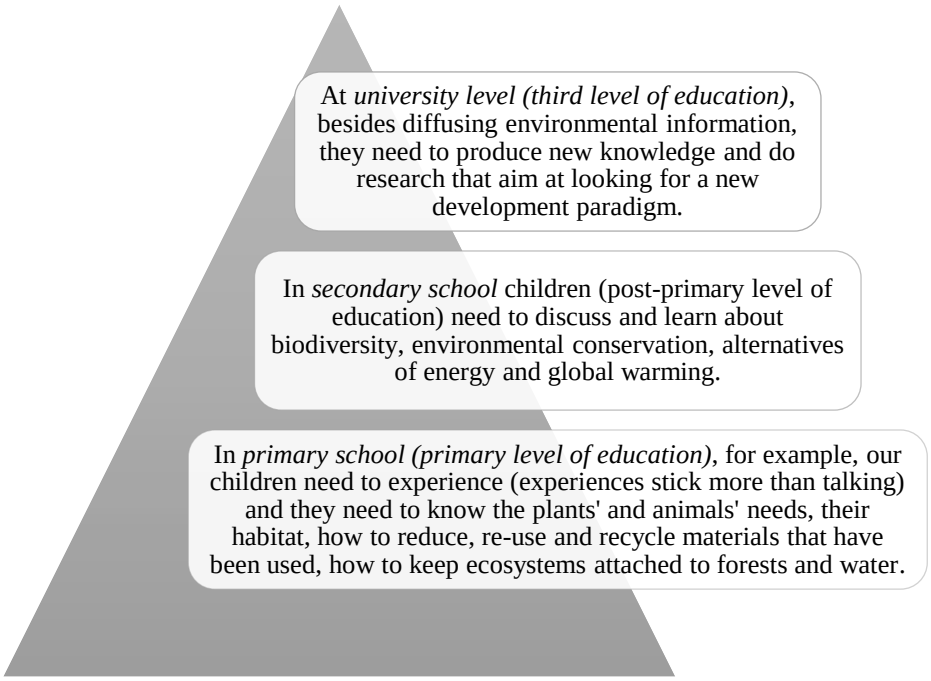


Figure 1.6. ESD at different leves of education (Gadotti, 2008)

University education (Sukitsch et al., 2015) is the one that plays a key role in disseminating knowledge and skills in the field of sustainable development research through:

- Providing strategic or operational models, as well as good practices (scientifically substantiated, tested and validated by research);
- Modeling the critical reflection and adaptive behavior approach;
- Building a knowledge base (libraries, online repositories et al.) rich for collaborative learning and knowledge dissemination and sharing.

In this level of education, active and participatory learning methods are recognized as adequate to improve and develop skills related to sustainable development, which can trigger a deep understanding of the problems (as the PhD programs can assure) and lifelong learning. However, inclusion of such learning methods in higher education is often difficult because of the large number of students per series and the complexity of the teaching and tutoring processes (Tormey et al., 2008; Starzyńska and Hamrol, 2013).

Essentially, UNESCO initiatives and programs on ESD aim to raise awareness amongst the population (from children to adults, students or employees, consultants or managers, civil servants or policymakers) of the importance of behavioral change caused by the challenges of sustainable development. Therefore, ESD requires awareness and behavior to adopt ethical values and principles that are related to people's sustainable lives and the survival of the Earth planet itself. In this context, the new Global Action Programme on ESD can be considered a call for transformation action, a popular education, education and planetary citizenship demand, cross-cultural and inter-transdisciplinary dialogue, a message to promote a cultures of peace and sustainability that promote the end of poverty, illiteracy, political domination and economic exploitation in the world, and all this through education for emancipation (Tormey et al., 2008).

Solutions for private-public partnerships for sustainable development

In Romania there are a number of initiatives that contribute to improving education for sustainability.

a. *Aquademica and Aquatim innitiatives for environmental and water education* - Since 2013 Aquatim SA Timisoara, the water provider company, has been supported and developed a series of projects that has been dedicated to ESD (financial supported by different companies, banks or foundations). One of the most successful solution of ESD is the Experimental Center for Children AQUAPIC. Aquapic has been developed in the last years with extension to experimental games (a collections of developed laboratory experiments that are associated with their usefulness and impact on real/common life).

b. *Timisoara Community Foundation social and communities impact initiatives* - Timisoara Community Foundation develops various projects dedicated to social dimension of sustainability. The main projects and initiatives are presented in the following:

- Timotion is more than just a sporting event, which brings in the sporting life of Timisoara a series of challenging trails that can be traced to the event, it is an event that gives rise to other events, projects and friends, supporting social cases. At Timotion (events that took place in 2016, 2017, 2018 and 2019) you run for the

projects and the people you believe in! Participants in Timotion races can be encouraged by donations, who go to the projects they support.

- The Donor Circle is a program developed by the Timisoara Community Foundation, which aims to create a network of individual donors to discover, promote, support, grow and connect creative projects with potential supporters and donors. Until now, the Donors' Circle has enjoyed three successful editions in Timisoara. The first edition of the Donors' Circle in Timisoara took place on 8 December 2016, the second on May 18, 2017, and the most recent on October 17, 2017. During this event, we set out to support many valuable projects for the community. The last Donor Circle was entitled Independent Together - The principle underpinning the Donor Circle, namely that every man fond of an idea, however foolish it may be, has the wonderful ability to attract others into his circle and to attract all the resources needed to accomplish it, acquires new valences at this edition. The Foundation believes in the power of each to shape the communities they live in, believes in the voices of the community, but most of all they think that the biggest impact is the projects developed together; the Foundation put the light on two independent platforms in Timisoara that aim to make the voices of the listening community.
- FACEM is a financing fund established to support the development of the community spirit and the quality of living in Timisoara. The program supports grassroots initiatives with power, for example, involving communities (block, stairway, and neighborhood) in areas such as cleanliness, leisure time, childhood, green spaces and patrimony. Through the program is motivating the inhabitants to reactivate their civility and willingness to collaborate in projects that will bring them the joy of knowing each other, living and doing things together. Whether we are talking about a neighborhood celebration or redevelopment or use of common spaces, people create connections by spending time together, which makes them build trust in each other.
- And other initiatives developed that were really successful.

c. *Smithfield Romania CSR education initiatives* - In 2017, the company invested one million lei in the “Adopt a School” program which wish to support an educational institution. The program was launched in Timisoara in 2017 at Smithfield Romania. It aims to improve the educational process and the study conditions in the schools in Timiş county and was initiated in partnership with Timiş County School Inspectorate. The pilot project ran from January to June 2018 and involved a total of 25 county schools, each benefiting from financial support from Smithfield Romania for implementing specific investment projects. Eligible projects included school infrastructure rehabilitation and renovation activities, procurement and endowment of new ITC teaching equipment, or the setting up of playgrounds and sports facilities in the schools selected in the program. This project benefited, at this stage, from the approximately 10,000 pupils and teachers from the 25 primary and secondary schools. Almost 300 teachers were directly involved in its implementation. In total, the amounts allocated by Smithfield Romania for the implementation of the pilot project "Adopt a School" are close to 195,000 euro. They were

allocated according to the size of the educational units and the investments were directly coordinated by experts from Timiş County School Inspectorate.

d. *City Hall of Timisoara, Environment Directorate* - The public body of Timisoara is very active in supporting different local projects for environment protection and quality assurance.

e. *Multinational company from the automotive industry* - The children have the opportunity to learn within the company the profession of die-cutter. Since 2013 and until now scholarships worth about 20,000 euros have been paid. In 2014, the high school was financed with the sum of 7000 euros, for the renovation and the modernization of a class of course.

f. *Banks cooperate with universities and primary schools* to improve the level of financial education. This approach contributes to improving the knowledge of young people and increasing the level of financial training.

The proposed framework for an efficient education for sustainability

By evaluating the benefits of private-public partnerships, it can be concluded that these efforts are delivering results for sustainable development. Private companies have strong practical competences, and state institutions have the share of knowledge. The following is a framework for an efficient education for sustainability year, based on private-public partnerships, Figure 1.7.

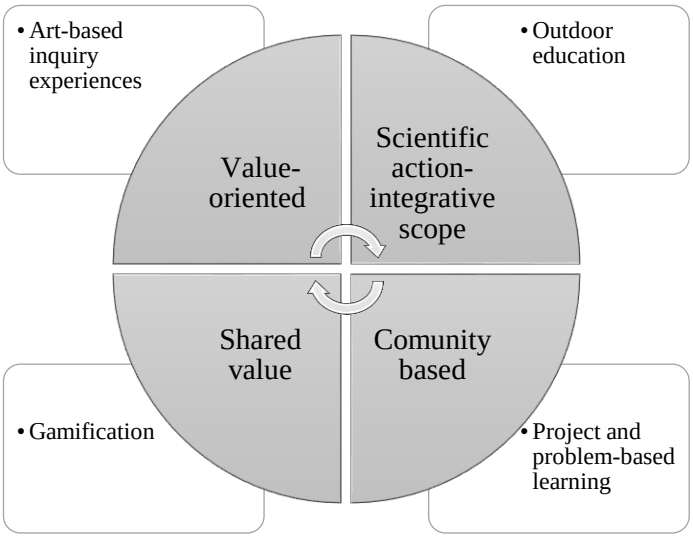


Figure 1.7. The proposed framework for an efficient ESD

As a general conclusion, Fig. 3.1 presents the proposed framework that could be adopted for encouraging policy-makers responsible for teacher professional development to enhance the coverage and possible impact of their programs, with a wider scope and clear objectives. Furthermore, it might serve as a guideline for teachers when they need to identify proper courses, training programs for their professional development in the field of ESD (continuous teacher training towards sustainability).

In addition, as regards summarizing ideas in the literature and considering the diversity of areas and methods of promoting sustainability in early childhood education, we believe that more action is needed to share ideas and examples of good practice for them can be adopted and adapted to new learning contexts. A first step would be for ESD to be an integral part of civic education. The concept of citizenship can be a useful way to understand the magnitude and complexity of necessary changes within a local community, and through ESD, children can act as agents of change, as transformers of the honey they live in by applying the values and principles of sustainable development. Furthermore, civic and civic education, as interdisciplinary teachers-supported approaches, can help to increase children's ability to act, think critically, identify problems and solve them through projects (pedagogical methods in ESD). All this can empower future generations to think and act differently to create a better and more sustainable world.

ESD is interdisciplinary, being transversal and beyond disciplines; it goes more to the fundamentals of multicultural citizenship and it is strongly linked with the way we interact with our context in our everyday life.

At the national level, Romania Ministry of Education should be more active in supporting and encouraging ESD by generalize the best practices in the field and reconsider the education plan for eliminating (merge some subjects) those disciplines that are considered boring and non-useful by the children. ESD is a terrible important alternative that should be considered for the increasing of the schools' attractiveness and prestige.

These private-public partnerships contribute to improving the level of education for Sustainability. These partnerships help to achieve "synergies for Sustainability". Organizational sustainability is an optional step for organizations, but the implications have been growing in recent years. It can be seen that there are partnerships in various fields of activity, but the benefits are considerable. The implications of the organizations are increasingly intense, and results are observed in the education level of the society.

Sustainability education is an important pillar for addressing sustainability within organizations. Below are presented a series of developed approaches that can contribute to improving organizational competitiveness.

1.2. Approaches to sustainable development in competitive organizations

1.2.1. Introduction

In 1951, the International Union for the Nature Conservation published the first report of a state on the global environment that is seeking a reconciliation between economy and ecology. 1960 has a less favorable importance as economic activities have a negative impact on the environment. Even if zero production would be reached, environmental protection and economic growth are highlighted as incompatible (Izvercianu, 2010). In 1970, Barbara Mary Ward, founder of the International Institute for Environment and Development - IIED, created and introduced the term sustainable development. 1972 Conference of the United Nations on human environment, Stockholm, presents a new model of economic growth compatible with environmental protection and social rights. Starting with that year until present there have been

raised over 60 interpretations of this concept, including social welfare, environmental protection and economic development. In 1973, E.F. Schumacher presents the concept of economic development at local level.

In 1987, the World Commission on Environment and Development, headed by Gro Harlem Brundtland gave the first definition of sustainability. The commission addressed a new generation of environmental issues directly related to the issue of sustainable development. The commission report of 1987 entitled "Our Common Future" highlighted how sustainability can be proven, with a constant concern for the environment, social respect and economic monitoring. WCED defines sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Ivascu, 2013).

In 1987, sustainable development was defined according to the resources of future generations because a limitation of these resources is not desired. In Rio de Janeiro in 1992, takes place "Earth Summit", which was attended by representatives from about 170 countries. As a result of this meeting several conventions on climate change were adopted (reduction of methane and carbon dioxide), biological diversity (conservation) and stoppage of massive deforestation. Also, a plan to support sustainable development was established, Agenda 21 (Ivascu, 2013).

Following these international concerns for sustainable development in 2002 was held in Johannesburg (South Africa) the World Summit on Sustainable Development, which analyzed the fulfillment of the objectives set a decade ago in Rio de Janeiro. At the World Summit in Johannesburg, besides exhaustive analysis "of the past decade" since the World Conference in Rio de Janeiro, they set new directions for action. The Johannesburg Declaration proposed collective responsibility for the progress and development of the three interdependent pillars of sustainable development: economic development, social development and environmental protection at the local, national, regional and global level (Report).

From 20 to 22 June 2005 in Rio de Janeiro, Brazil, the United Nations Conference on Sustainable Development was held, or Rio + 20. As a result of this meeting there has been developed a focused document that contains clear and practical measures for implementing sustainable development. In Rio, the member states have decided to start a process of drawing up a set of objectives for sustainable development (Sustainable Development Goals-SDG), which will be based on the millennium development goals and are converging with the development agenda post 2015. The conference adopted also innovative policy guidelines on green economy (Platform for the sustainable development of the United Nations, 2013).

This action and principles are applicable now also, so that the objectives of sustainable development converge towards: action orientation, concise objectives, easy to communicate, limited in number, aspirational, global nature, universally applicable to all countries taking into account the different national realities.

The European Commission launched in 2000, the instrument "triple baseline" for measuring value, the subordinate elements of this approach are: the environment, and the

economic and social environment. Within another research in 2008 (Izvercianu, 2008; Yunus et al., 2010), there is present another subordinate namely "technological responsibility", which today probably is integrated in each dimension because technology has become a support for each activity being included in any activity. The triple baseline generates the triangular theory: terms like 3E's: equity, environment, and economy; or 3P's: people, planet and prosperity (Zimmerman, 2005), Table 1.6.

Table 1.6. The triangular theory (3Es, 3Ps)

Triple bottom line	Social	Environment	Economic
3E	Equity	Environment	Economy
3P	People	Planet	Prosperity

Sustainability refers to the ability of durable that persists with time. So, in (Shuo, Wei, 2013, p. 809) "…The essence of sustainable development is creating environmental and social conditions for earth enduring system, so that can benefits mankind. It clearly indicates the absolute dependence of human on earth enduring system". Analyzing the evolution of the concept of sustainability is obtained the Table 1.7 (Ivascu, 2013).

Table 1.7. The evolution of sustainability

Year	Declaration
1951	International Union for Conservation of Nature - the first report on the global environment
1960	The economic activities have a negative impact on the environment (degradation, pollution, smoke, plants, et. al)
1970	Club of Rome denounces stopping of production
1972	Stockholm Declaration - economic growth model (ECO development - ecological development)
1973	E.F. Schumacher presents the concept of local economic development
1974	Church Council on sustainability theory lays the foundation defining four topics (the company, the board of pollutants resource renewable, climate)
1987	WCED (World Commission on Environment and Development) - "Our Common Future" which launched the concept of sustainable development.
1992	"Earth Summit" in Rio de Janeiro - Agenda 21 and various environmental conventions and supporting change
2002	Johannesburg, Summit – sustainability development (Rio+10).
2005	Rio de Janeiro, United Nations Conference on Sustainable Development or Rio +20
2008	Two Tiered Sustainability Equilibria (TTSE), where the issues in each aspect (economic, environmental and social), interact with each other, with issues in other aspects, and through time (Lazano, 2008).
2013	The essence of sustainable development is creating environmental and social conditions for earth enduring system (Shuo, Wei, 2013).
2014	Developing a balance of enterprise by integrating: economic, social, environment responsibility, and through the technological support (author).

The foundation of the requirements for sustainable development was set in 2000 by the European Commission. This Commission launched on April 2000 the tool of "triple basis line" on the request of measuring their value, having as subordinated issues:

- *environment*: the impact of the campaign activities on the environment broadly – natural resources usage, rejecting the entire nature, territory occupation;
- *economic*: collecting financial performances, their impact on the economic growth in their field of activity and obeying the ethical principles in business;
- *social*: the social consequences of the company as a whole its representatives: employees, solicitors, clients, local community (European Commission, 2013).

Analyzing the definitions presented in Table 1.7, we see that the concept of sustainable development shows adaptations and interpretations over the years. In theory, taking into account the subordinated issues (economic, environmental and social) a balance cannot be realized without the real support of technology. Partially, technology is included in every aspect, but technological evolution and optimal technological solution for the three aspects is a separate balance. The sustainability development can be seen as an additional requirement in the development of organization processes and achieving the objectives' enterprise.

Analyzing the above definitions, we can outline a picture of terms used mainly in the definition of sustainability. This image differs in time, existing a difference between interpretations of different authors over time.

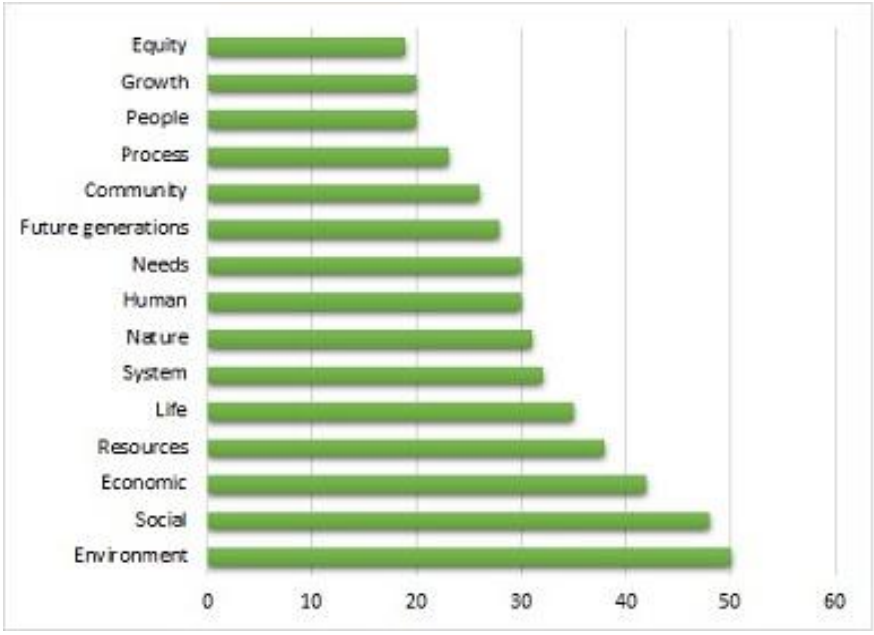


Figure 1.8. The 15 keywords used in defining sustainability within the 100+ definitions analyzed (after White, 2013; Ivascu et. al., 2013)

As shown in Figure 1.8, the 5 most used words in the definition of sustainability are: environmental, social, economic, resources and life. Based on the above there can be deducted the characteristics that an organization must have on its way to sustainability. So the

organization's characteristics to a sustainable direction can be outlined as follows (Jackson, 2009; Romero et. al., 2011; Cioca et. al., 2015):

- The organization encourages minimizing resource consumption (renewable energy, water management, waste reuse, etc.);
- The organization is designed to maximize environmental and social benefits, rather than to maximize revenues (economic growth);
- An organization with cyclic circuit in which nothing but is wasted everything is reused;
- An organization that emphasizes delivery of functionality and experience, rather than product ownership;
- The organization is inclined towards employee involvement and its creativity in the processes carried out, and not to "exploit" the human resource in favor of stakeholders;
- The organization is directed toward educating and developing an organizational culture, rather than to pursue economic growth;
- The organization is built to share knowledge and collaborate, rather than aggressive competition.

Initially, since 1951, the definition of sustainability was associated with the environment. Later, in the early 1970s, with this term there were associated also the social and economic subordinate. Gradually, the sustainability had various interpretations, and in 2000 there were clearly defined by the European Commission the three dimensions: social, economic and environmental. After 2000, the concept was addressed in a balanced manner, so that in 2010 to be associated mainly with environmental and social activities (Ivascu et. al, 2014). Currently the focus is on the energetic side, with efforts being made in the use of renewable energy and waste management (Cioca et. al., 2015; Bocken et al., 2012; Bocken et al., 2013).

The sustainable development models applied in practice

Global Reporting Initiative (GRI) is probably one of the most popular initiatives that develop and disseminate global applicability of sustainable development based on guidelines that are based on economic, social and environmental performance. This concept became the inspiration of many national and international businesses, organizations, and academic institutions to rediscover the ability to use the instrument for the measurement and evaluation of sustainability process. Thus, we can consider that the sustainable development of the organization is a continuous process of improving environmental, economic and social performance of the organization (Staniškis and Arbačiauskas, 2009; Tukker, 2004). The most used methods and tools for evaluating the sustainability of the company are based on indicators, but there is no general tool available to all organizations. Table 1.8 presents the existing tools for evaluating sustainable development, based on a review of the literature.

Table 1.8. Tools for risk assessment presented in chronological order

Author, year	Conceptual Model/Business model archetype	Implications of model	Main sustainability benefit
Allee, 2000	A value network perspective	Business Models	Revenue, Knowledge, Intangible benefits
Hart and	Sustainable value	Sustainable value	Shareholder value, clean

Milstein, 2003	framework	creation	technology, product stewardship, pollution prevention
Wells, 2004	Business model in the automotive industry	Automotive industry	Sales growth
Brugmann and Prahalad, 2007	Categorizing social enterprises	Sustainable development	Social benefits
Stubbs and Cocklin, 2008	Conceptualising sustainable business model	Organizations development	Develop internal structural and cultural capabilities to achieve firm-level sustainability
Birkin et al., 2009	Business model on manufacturing company	New business models on China	Improving performance
Shrimali et al., 2011	Business model	Profitability	Financial sustainability
Høgevold, 2011	Corporate effort to implement a sustainable business model.	Green business models	Green concept
Bocken and Allwood, 2012	A novel tool to facilitate the reductions in greenhouse gas emissions (GHG)	Collaborating across the value chain	Reduced GHG
Barber et al., 2012	Business model	Green business models	Environmental sustainability
Schaltegger et al., 2012	Business model innovation	The business case for sustainability;	Corporate sustainability
Bisgaard et al, 2012	Business model and conceptualisation	Value creation and business models	Standard activities
Beltramello et al. 2013	Business model	"green' business models	Global sustainability
Boons and Lüdeke-Freund, 2013	Corporate effort for sustainability	Business models for sustainability	Innovation
Ivascu et al., 2013	Enterprise model	Risk Management and Sustainability	Social, Economic, Environment, Technological

The literature offers a number of conceptual and business models for sustainable development of the organizations. These examples were collected and presented in a systematized way to identify models and characteristics of business. Note that currently the focus is on the energetic side, efforts being made for the use of renewable energy. Until 2012, many publications targeted their action to activities involving the company and therefore corporate social responsibility. Now, it is a redirection towards green energy concept, existing a number of opportunities for organizations.

Development of a sustainable business model archetype based on literature and practices

Based on business requirements and the evolution of national and international requirements, the objective is to develop a prototype that is easy to use and understand and to be managed in accordance with the objectives of each organization. This requires an easy to use interface that hides the complexity of a system evaluation and an interface that generates results easy to interpret. These are the requirements of any organization that aligns their objectives to the sustainable direction. The methodology for the development of a prototype is

based on a review of the literature and is then refined / selected by the conceptual models according to theory and depending on the models developed and used in practice, it constitutes a framework for systematizing a prototype. This cycle is shown in Figure 1.9.

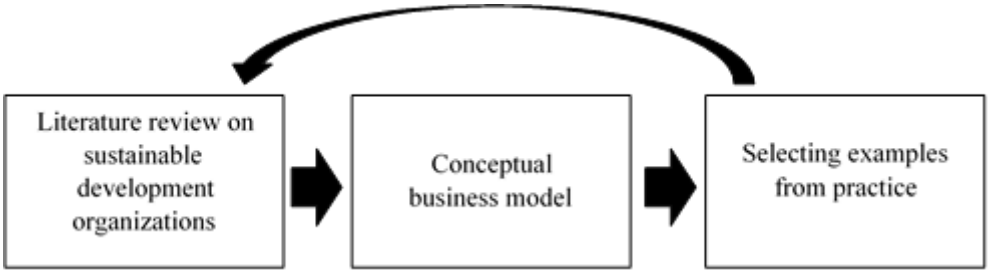


Figure 1.9. The stages to develop the archetype for SD

The following is the archetype for sustainable development of organizations (Figure 1.10). The archetypes are classified in groups of I order which shows the main types of business models that are oriented towards innovation: technological, social and collaborative. The archetypes are: waste management, maximize material productivity, energy efficiency/renewable sources, adopt a stewardship role, active involvement in the society, encourage quality, active involvement of employees, industry – education, and sharing the experience. For each archetype a series of examples are presented. Each archetype can be characterized as follows:

- Energy efficiency / renewable sources: use as little energy and use renewable energy (solar, wind, thermal, biomass energy).
- Waste management: manage the waste in accordance with environmental requirements; selectively collect and reuse.
- Maximize material productivity: produce more with fewer resources, developing less waste and pollution is lower. Thus the contribution to greenhouse gases is minimal.
- Adopt a stewardship rolls: the inclination to the employee; adoption of actions conducive to long-term health and wellness.
- Active involvement in the society: actions that support and contribute to the development of society (young people at risk, support campaigns, rural development, etc.).
- Encourage quality: supporting equality at work without differentiating the employees who are at risk.
- Active involvement of employees: employees contribute actively to the development of the organization through proposals and own actions.
- Industry-Education: collaboration with teaching institutions contributes to the development of organizations; teaching institutions (universities, colleges) contribute to the research and development area of the organizations.
- Sharing the experience: knowledge sharing contributes to the organizations development towards sustainability.

This structure presents an overview of the business environment, suggesting a grouping of organizations depending on the main direction of the activities developed.

The literature provides a vast support in the field of sustainable development, but updating the sustainable business models archetypes is a priority. The business environment is dynamic,

and the organizations establish their environmental objectives according to need. This research provides a unification of different models and concepts from literature, presenting the organization typologies and related activities to sustainable development.

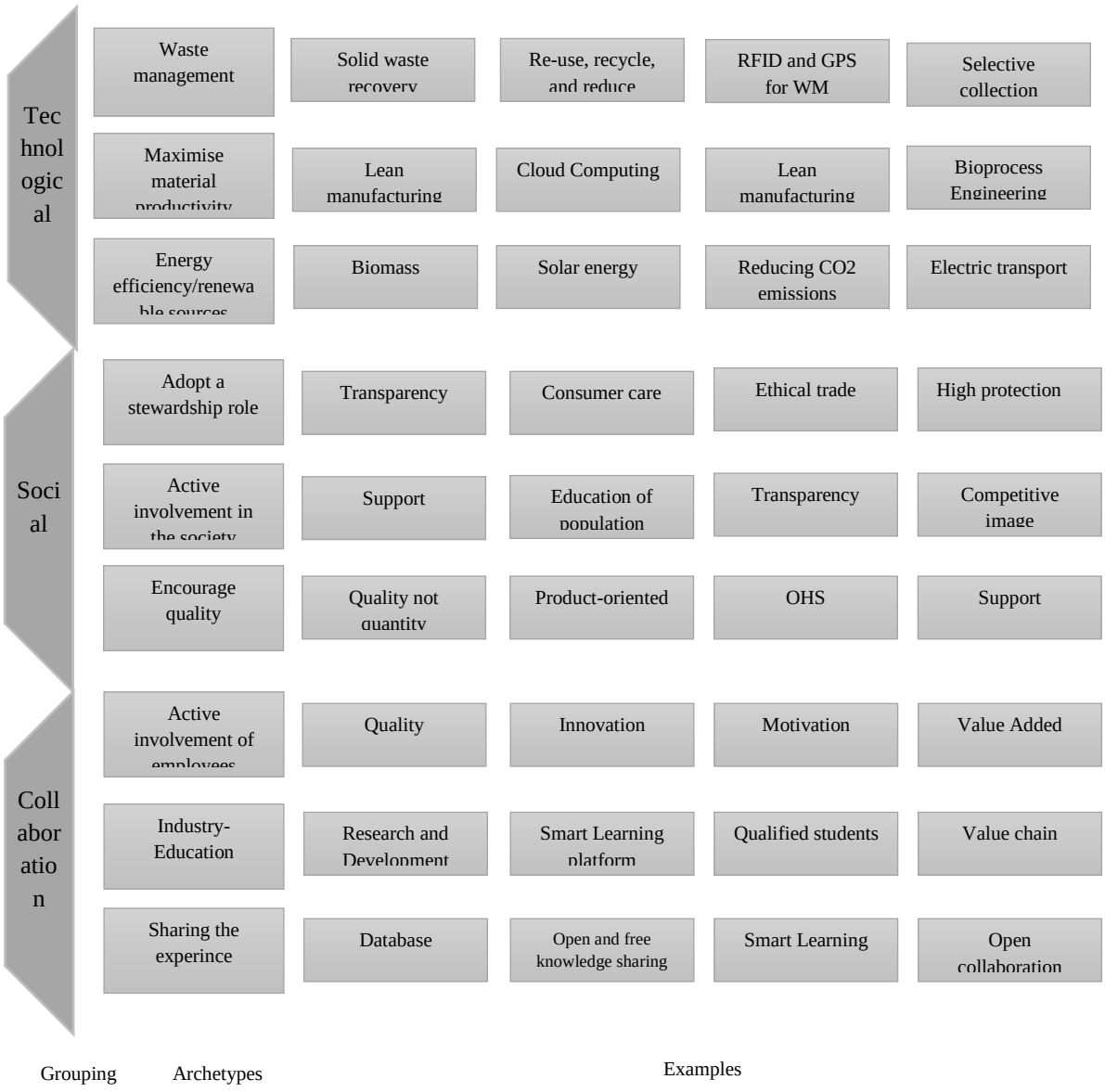


Figure 1.10. The sustainable organization model archetypes

1.2.2. Enterprise Sustainability Management

Sustainability is one of the latest "buzzwords" among businesses. The sustainability of an enterprise is always defined by future events, and the future is always uncertain. Sustainability Management integrates management concept in a sustainable setting. It is difficult to define a reference model for sustainable management of the enterprise. Therefore a holistic approach to enterprise sustainability management becomes emergent. Enterprise Sustainability Management (EMS) integrates the necessary components of sustainable development in

business processes. Enterprise Sustainability Management touches every area of the value chain: including product development, purchasing, sales, customer service, and others. EMS ensures sustainable enterprise development that meets not only their business needs, but also highlights the life and durability of the system in which it works. The paradigm of sustainable development requires rethinking of the way business works and of the management, leadership. Thus, the sustainability management will change the competitive landscape of the enterprise in the manner in which firms develop and use resources, capabilities and competencies. It becomes imperative for the enterprise that the corporate success is directly proportional to the sustainable development. For some organizations, sustainability is all about reducing energy for others to design eco-friendly products. In such a scenario, each organization defines its own system with its own leadership and its sustainable development model. Therefore, developing a model of enterprise sustainability becomes emergent. This model incorporates three basic pillars: knowledge management, risk management and leadership. This section explores an emerging model for sustainable enterprise development, current approaches of sustainability, directions and keys drivers. European Union directions are moving towards creating a balanced environment in which the enterprise to work and in which the future companies are able to develop their own activity. Managing and balancing business activity, in a fair way, becomes mandatory for every company. The presentation and analysis of these directions represents the support of this research, and also the validation of the proposed model for enterprise sustainability management.

Sustainability is a very important factor in maintaining long-term company success (Lindsey, 2011). The enterprises around the world are elevating resource efficiency and sustainability from a tactical to a strategic concern – and are moving aggressively to improve environmental performance in operating processes and products. This concept has led to new challenges for enterprise information and resource management, and also for processes control (Cioca et al, 2013). These challenges revolve around water use, environmental resources, solid waste, toxic materials, carbon emissions, and other elements within the organization and the value chain.

Today, the need for integrating sustainability into the company's management is due not only to minimize losses from the developed processes, but also to exploit new business Opportunities (Krechovska et al, 2014). As society evolves, businesses must adapt and manage this challenge. Therefore, environmental, health and safety, social and technological challenges lead to developing strategies in terms of people, processes and technology, namely Enterprise Sustainability Management. There are changes in society, the thinking and behaviour of people is changing, the sustainability is adopted, business environment is changing, with new trends and concepts being developed to which enterprises should react if they want to be successful. The process of globalization, changes of technology and sustainability are offering the possibility of creating higher values for the stakeholders (Menichini et al, 2013).

Sustainability of business involves the future enterprise, and the future is always uncertain. So, the future presents risk and opportunities. To support the enterprise long-term, risk management should be used. There is a bidirectional link between risk management and sustainability management. This section presents a model for enterprise sustainability

management in which the following are integrated: knowledge management, risk management and leadership.

Sustainability could be defined as a strategy of the process of sustainable development (Zborkova et al, 2011). Enterprise sustainability is understood "as the ability of a company, through its governance practices and market presence, to positively influence ecosystems (improving natural resources, reducing pollution levels, etc.), society (supporting local populations, creating employment etc.) and economic development (distributing wealth through dividends, paying fair salaries, respecting supplier payment obligations etc.)" (Krechovska et al, 2014). When integrating the concept of sustainability development, the enterprise should develop management models and strategies that will lead to the creation of social, environmental, economic and technologic values (Castelazo et al, 2014).

The overall objectives of sustainable development are diverse, complex and numerous. Among the objectives of sustainable development there can be systematized the following imperatives (Yilmaz et al, 2010),(Report, 2010),(Schaltegger et al, 2002):

Table 1.9. General imperatives of sustainable management

Significant imperatives	
Objective	Description
ESM is desirable and necessary	In a competitive and alert economic environment, this concept becomes mandatory to be adapted.
ESM requires effective achievement of targets in each of the dimensions-environment, economic and social	To adopt an ESM involves developing a balance between the three responsibilities of sustainability: environmental, social and economic with the support of technology.
Integration of environment, social and economic objectives is achieved	Creating a rapport between the enterprise objectives to the essential elements of sustainability is required in a sustainable system.
Acquiring and using good information	Using real information in the enterprise is an important pillar in the development of a sustainable management. Also communication is becoming an important tool to be used at a maximum level to share essential information.
Knowledge, risk and leadership become the pillars of EMS	You cannot develop an EMS if the risks are not identified in all processes, the leadership does not apply correctly, and knowledge management is not adopted in the enterprise.
Integrating sustainability into business process management	The implications of sustainability must become an essential part of strategic management and business plan.
Integrating sustainability in reporting company performance	Quantification of the results of sustainability in the economic performance and its impact on the growth of the shareholder.

Main challenges of enterprise sustainability management

The vision of sustainable development has three main dimensions: economic, environmental and technological (Folmer et al, 2005). The technology is the real support of these dimensions (Ivascu et al, 2011). Without technology we cannot talk about sustainable development (Lee, Sae, 2012) and the sustainability of the planet. The objective of sustainable development involves business enterprises with four sustainability challenges, Figure 1.11:

- Environmental challenge: increasing ecological effectiveness,
- Social challenge: increasing social effectiveness,
- Economic challenge: improving eco-efficiency and social efficiency,
- Integration challenge: bringing together the environmental, social, and economic challenges and the development eco-justice.

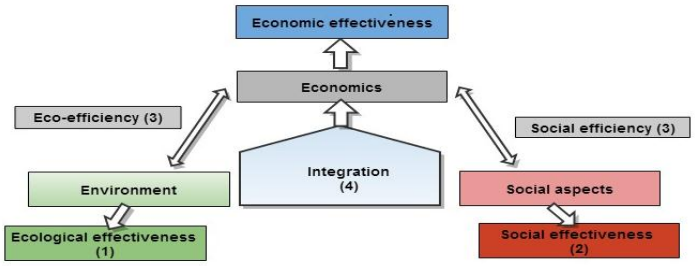


Figure 1.11. The sustainability challenges to enterprise: (1) environmental challenge, (2) social challenge, (3) economic challenge, (4) integration challenge (after (Yilmaz, 2010))

Sustainability development creates and maintains the conditions under which humans and nature can exist in productive harmony, that permit fulfilling the social, economic, environmental and other requirements of present and future generations (Krechovská et al, 2014) .

European directions in sustainability management

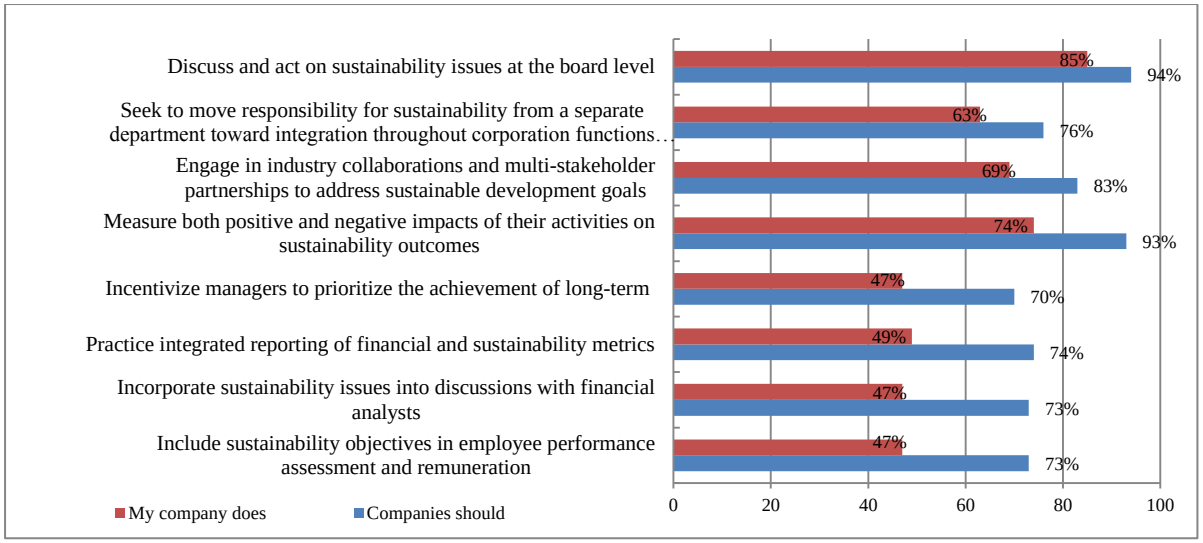
Sustainability is an approach adopted both nationally and internationally. Concerns for sustainable development and management are more and more intense. Through the research of the literature drivers and barrier can be systematized ((Piotrowicz et al, 2009), (Bond, 2010), (Smith and Baird, 2007)), Figure 1.17. These drivers contribute to the development of sustainability management and to maintain a durable balance in the system of the enterprise.

Table 1.10. Drivers and barriers to sustainability

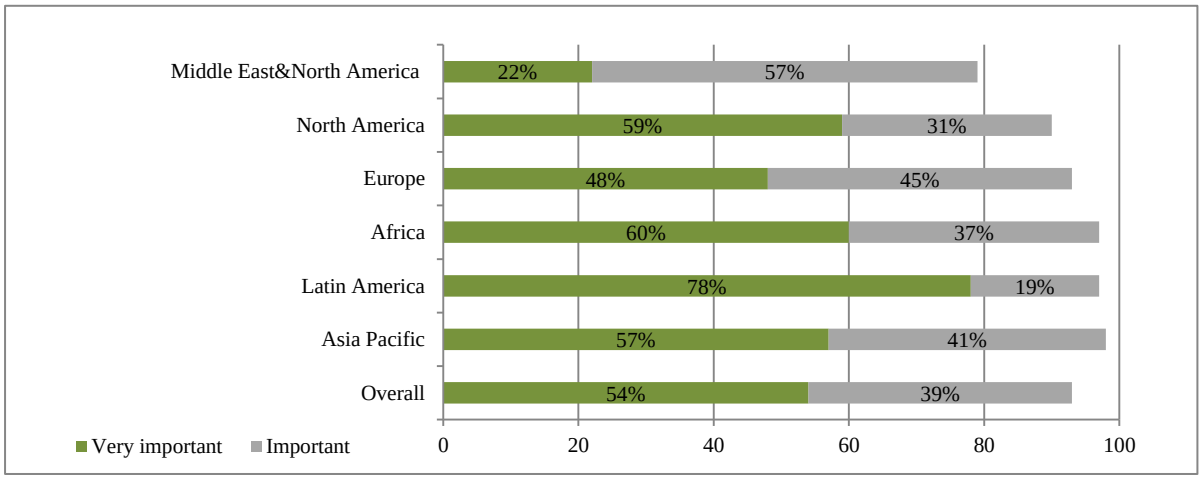
Drivers	Barrier
Leadership opportunities	Competing priorities
Corporate responsibility	Corporate responsibility
City/Local regulations	Lack of organisational support
Potential for innovation	Gap between theory & practice
International regulations	Lack of staff capacity and high staff turn over
Connectivity and communications	Communication is increasingly disaggregated across complex social networks
Consumer appeal	Inadequate legislation
Active and engaged community	Difficulty dealing with government agencies

Growing environmental concerns	Research and development challenges
Effective management systems	The language of sustainability
Partnerships and external agency support	Inadequate systems for managing information
Generate cost savings	Enterprise resource planning

In order to present a general and global image on sustainability and adoption of the practices enterprise management, the section present a series of topical studies found in the literature. There are presented the results of two axes: the importance of the sustainability in business, Figure 2 (a), and "performance gap" between ambition and execution on sustainability, Figure 2 (b). United Nations Global Compact and Accenture have released the findings of what they say is the largest CEO research study on enterprise sustainability. This is UNGC-Accenture CEO Study 2013, based on 1,000 completed responses; 2007 data from UNGC-McKinsey study, with comprehensive interviews with many of the largest companies.



(a)



(b)

Figure 1.12. (a) Companies continue to demonstrate a “performance gap” between ambition and execution on sustainability; (b) How important are sustainability issues to the future success of your business (Accenture, 2013).

In Figure 1.12 (a) there is presented the data issue "performance gap" as the company says it is actively involved in the sustainable development of the enterprise, but in fact there is a gap to execution. To systematize these data there were considered to the following factors to exemplify: include sustainability objectives in employee performance assessment and remuneration; incorporate sustainability issues into discussions with financial analysts; practice integrated reporting of financial and sustainability metrics; Incentivize managers to prioritize the achievement of long-term; measure both positive and negative impacts of their activities on sustainability outcomes; engage in industry collaborations and multi-stakeholder partnerships to address sustainable development goals; seek to move responsibility for sustainability from a separate department and discuss and act on sustainability issues at the board level. Note that in most cases there is a performance gap of about 20% -25%. So sustainability management practices should be planned and applied in full to minimize the performance gap.

In Figure 1.12 (b), it can be seen that the whole world has been paying a very high importance to sustainability and its integration in enterprise management. The highest percentage was obtained by Latin America, for which the importance of sustainability reaches almost 80%. In Europe, the sustainability balances between very important and important.

Enterprise sustainability management - A proposed model

From literature research we can say that sustainability is seen as a driver of innovation tools for leadership, and improving the top line / bottom-line. Keywords associated with this statement are innovation and leadership. So to develop a sustainable enterprise management the section presents the proposed architecture with the pillars: innovation (through knowledge management), leadership and risk management. All these concepts apply to a secure environment, that means for which an assessment of risk is required. In a secure environment, the objectives achievement and the enterprise development are real imperatives. Thus, we included a new level of the proposed model: risk management.

Enterprise Sustainability Management requires holistic and systematic integration of economic, social, and technical factors in the business management. Businesses are always focused on financial performance and to achieve operational goals.

The model proposed, Figure 1.13 shows five-level architecture of the essential capabilities for sustainability management at an overall enterprise level down to the device level. Lastly, we present a series of recommendations for how enterprises can develop effective enterprise architectures for sustainability.

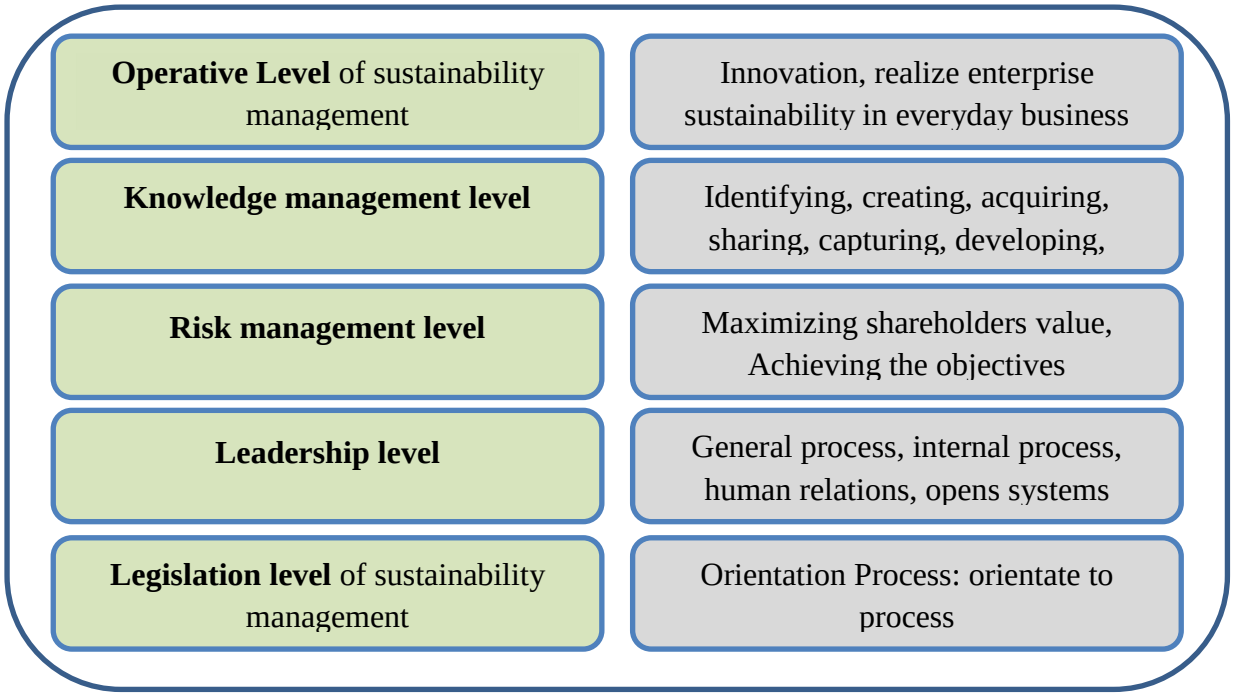


Figure 1.13. An emergent approach of enterprise sustainability management

Legislation level

Each company operates under national and international laws. To develop a sustainable management, the enterprise must align, first, to the sustainability imperatives associated with the responsibilities: economic, social and environmental. Also, the company must adopt the new technological developments, so the information management systems are not an obstacle to sustainable development. Without real support from technology, enterprise sustainability management would not be able to be implemented.

Leadership level

National and global changes in the economy due to globalization, sustainable development requirements, the struggle for competitiveness and fiscal crisis combined with the complexity of internal business environment have modified significantly the role that professionals are called to play (Rothacke et al, 2014). In this context, managers have to face many new challenges including evolution of information technology, increasing competition due to globalization, the importance of the strategic management perspective, demands for transparency, the emergence of sustainability and the ever increasing importance of human resources management.

So these managers play three types of roles that are at the foundation of sustainable management: producer and director (general process), coordinator and monitor (internal process), facilitator and mentor (human relations), and innovator and broker (open systems) (Trivellas et al, 2014). In each role, the leader is required to have key competences and internal actions. So the next level in an enterprise sustainability management consists in leadership level.

Risk management

Risk is a part of every human activity (Wu et al, 2014). Risk management is an organized process designed to aid in achieving the objectives. It is important to identify risks through an ongoing process and they should be monitored and the new risks to be relevant. Technology and technique is developing extremely quickly so we should not be ignored the associated characteristics and risks of each company. Systemic vision of the stages of risk management contributes to optimal integration of methods and techniques for hazard identification and risk analysis in the assessment process. Risk management is a continuous cyclical process that represents the coordination of activities to identify hazards, assess, control, monitor and treat risks to achieve a balance between costs and benefits and the achievement of business objectives (Ivascu et al, 2014). The organization should implement process using a risk-based and sustainability perspective to assess, avoid, reduce, transfer and mitigate environmental risks and impacts from its activities. An enterprise should develop and implement awareness-raising activities and emergency response procedures to reduce and mitigate environmental, health and safety risk caused by accidents and to communicate information about environmental incidents to appropriate authorities and local communities (ILO, 2012).

Knowledge management level

Knowledge represents the ability to sustain the coordinated deployment of assets and capabilities in a way that helps the firm achieve its goals (Lapina et al, 2014). To the enterprise, knowledge is defined as what people know about customers, products, processes, success and environment (Ishak, et al, 2010). According to Sumi (2011), "KM is a managerial philosophy, which is perceivable in the practices of different organizations. Utilizing KM, better performance can be achieved by interaction between individuals or groups. Moreover, to be efficient, KM requires storage for information and knowledge, which is open to organization member for searching critical information, knowledge or the best practices. Thus KM is the learned method for knowledge sharing and interaction and furthermore, KM clarifies which way to operate. KM should be considered an organizational process, which is used to achieve better performance due to effective knowledge sharing and organizational learning, recognizing and developing competencies, and gaining from individually different skills and

Knowledge". Therefore, without optimal management and use of knowledge within the enterprise the processes can meet deficiencies, and relationships between employees can be distant. So enterprise processes involved in knowledge management includes the capability of data and information processing using computational techniques and the capacity for innovation and creativity of people. Knowledge management optimally uses existing and available knowledge in the enterprise in order to create in this process new useful knowledge.

Operative level of sustainability management

At the operational level the previous concepts and theories are systemically integrated for the enterprise to work in a balanced way. Without systemic approach to resources and processes within enterprise the balance would have swings. In this last level it is achieved an innovative mix between knowledge management, risk management and sustainability. Providing visibility

into operations, operative level is being utilized to establish risk-related business processes, manage change, monitoring risk analytics, and leverage the effectiveness of corrective, preventive ant control actions.

As society evolves at a rapid pace, the businesses must keep up the pace and adopt new strategies in the terms imposed by sustainable development. Enterprise Sustainability Management is a holistic approach that allow enterprises to address a series of challenges associated with environmental, health and safety, risk management, product stewardship, natural resources, corporate social responsibility and waste. A proactive risk management contributes to optimal decision making under risk and uncertainty and inefficiency or misconducted risk assessment can directly affect the company's objectives and results. A leader has the skills necessary to "play" the role of an actor that optimally manages the enterprise resources.

Therefore, integrating these concepts into a model contributes to economic environmental sustainability and to achieve the objectives of the enterprise. The purpose of this part is to propose an emergent framework for enterprise sustainability management. The originality of this approach is that it integrates the traditional approach to management combined with the imperatives of the current economic environment. Enterprise model authors often refer to the necessity of aligning strategy and the business model. Both are important concepts of sustainability management.

1.2.3. Evaluation of Sustainable Development Requirements for Companies

The concern for sustainable development has made most companies to integrate the principles of this concept in their proceedings. Sustainability is an important endeavor which takes into account not only the environment but also economic and social factors. Therefore, this concept implies some interdependence between the three dimensions, so neither can exist without the other. However, companies concerns are many and various so only some of them manage to fully engage in sustainable development. Projected indicators in reporting initiatives are mainly partial fulfilled by companies. Because of this, climate change issues also intervene and they are affecting the world more and more. Concerns and activities of people and companies are contributing to greenhouse gas emissions that lead to these changes. In case the emissions of greenhouse gases would fall in legal standards, the situation would change. This is the purpose of this part, to highlight the minimum requirements to be met by companies to contribute to sustainable development and to present a review of the current situation.

The economic context, structures and policies create the environment for sustainable development (SD), but individual business operations are responsible for the production of goods and services. The personalized technologies that they use have a significant impact on the quantity and types of materials used in the production cycle of products. In the past, the impact of different technologies on the environment was not an important issue for business planning and operation over a long period of time. Instead, today, due to the large number of companies and the high level of pollution due to the intensity of production, sustainable development becomes a long term requirement. Concerns for the environmental impact of business activities have become a reality for most companies in the latter part of the 20th

century. Chemical pollution, variety of industrial accidents, public opposition to logging and mining operations, and the discovery of human impact on the global system are some of the current problems existing in the world.

Global climate change

The average global temperature in 2013 was 14.6 ° C (58.3 ° F), which is 0.6 ° C (1.1 ° F) higher than the mid-20th century (NASA, 2016). The average global temperature increased by about 0.8 ° C (1.4 ° F) from 1880, according to the latest studies (since January 2014) analysed by NASA Goddard Institute for Space Studies (NASA, 2016). Analyzing the signifying events that show abnormalities, at the level of July 2016, it is observed that globally there are some atmospheric weaknesses: intense precipitation in Europe, excessive heat in Asia, rainfall 61% above average in Australia, high temperatures in America and others. According to the map, the temperatures are much higher than average, including most of the world's oceans during the month of July 2016 with surface temperatures record high in western, southwestern, central and southeastern Pacific Ocean, Indian Ocean north East and southern and western Atlantic Ocean. Cooler than average conditions were identified in parts of southern oceans. The only area of the ocean with record low temperatures was east of the Drake Passage off the southern tip of South America.

The Intergovernmental Panel on Climate Change (IPCC, 2016) published the sixth review of the analysis of scientific, technical and economic information and concluded that the evidence for human-induced climate change have become increasingly powerful (Cioca et al., 2015). Greenhouse gases (GHG) are the principal atmospheric constituents that contribute to climate change, they are natural and anthropogenic gases that absorb and emit radiation at specific wavelengths spectrum of infrared radiation emitted by the earth's surface, atmosphere and clouds. The increase of GHG emissions due to human activities have led to global atmospheric concentrations substantial increase of long life gas and other effects of emissions. Every country in the world emits greenhouse gases into the atmosphere, leading to the hypothesis that the main driver of climate change is truly global in scope. The activities of companies are intensive and for this reason this sector, together with the residential sector emit the largest amount of GHG and carbon dioxide in particular. Therefore, companies' practices are very important and help to reduce emissions locally, nationally and globally (Cioca et al., 2011).

Sustainable development in the current context

Globally, there is an increasing trend of providing economic, social and environmental information to companies. It is internationally recognized that the reporting of sustainability leads to improved business performance by communicating with groups of stakeholders such as customers, suppliers, employees, financial institutions, regulators and management communities of an economic company, environmental and social performance (Roopinder, 2012; Cyriac, 2013). Unlike financial reporting, sustainability reporting process (SR) is relatively recent. Sustainability reporting process must complete financial accounting activities with accounting environmental performance, social and other "non-financial" (Roopinder,

2012). In 1992, the United Nations Conference on Environment and Development, very few companies were involved in sustainable development.

In most studies of the implications of sustainable development the evaluation is performed using three dimensions (social, economic, environmental), being called triple bottom line approach (Figge and Hahn, 2002; Figge and Hahn, 2012; Siew, 2015).

Sustainable development requirements for companies

According to the G4 Sustainability Reporting Guidelines (GRI, 2016), categories and issues to be included in the reporting of the company are systematized in 3 dimensions: Economic, Environmental, and Social. The aspects to be assessed are:

a. *Economic*: economic performance, market presence, indirect economic impacts, and procurement practices.
b. *Environmenta*l: materials, energy, water, biodiversity, emissions, effluents and waste, products and services, compliance, transport, overall, supplier environmental assessment, and environmental grievance mechanisms.
c. *Social*:
    i. *Labor Practices and Decent Work*: employment, management, relations, occupational health, and safety, training and education, diversity and equal, opportunity, equal remuneration for women and men, supplier assessment for labor practices, and grievance mechanisms.
    ii. *Human Rights:* investment, non-discrimination, child labor, forced or compulsory labor, security practices, indigenous rights, assessment, supplier human rights assessment, and human rights.
    iii. *Society*: local communities, public policy, anti-competitive behavior, compliance, supplier assessment for impacts on society, and grievance mechanisms for impacts on society.
    iv. *Product Responsibility:* customer health and safety, product and service labeling, marketing communications, customer privacy, and compliance.

These indicators must be provided in the reporting companies. In the analysis reports for companies from Romania, published reports on the companies' websites were used. There were considered the top 100 companies in a ranking conducted in the western region. Through an analysis of reporting companies in Romania it is observed that only 33% of them are reporting using GRI G4, while 70% report their work in a form endorsed in their own regime, Figure 1.14. Of the companies analyzed it is seen that 52% evaluate the three dimensions in their reporting, while 22% focus on assessing environmental and social dimensions, and economic and environmental. The complexity of reporting has increased in Romania since 2010, when only 30% of managers surveyed in a research understood the implications of the concept of sustainable development (Izvercian et al., 2014).

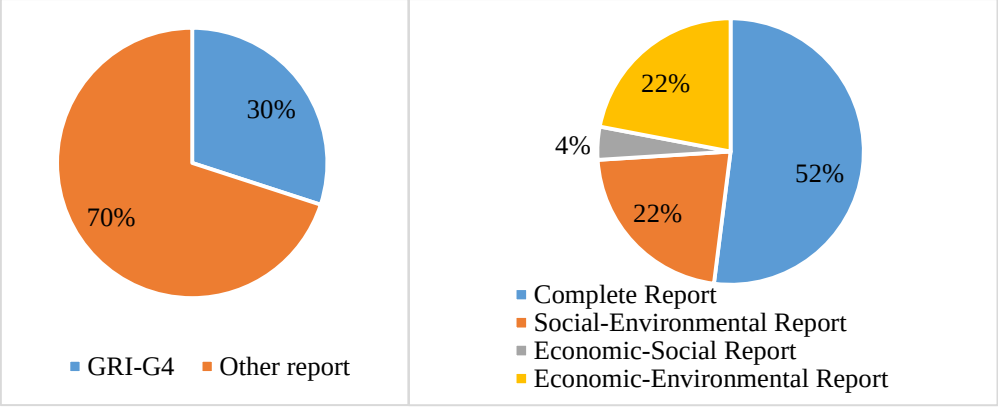


Figure 1.14. Sustainability reporting in Romania

In the study by Cyriac in 2013, it is observed that the number of Indian companies who publish their sustainability report is very low. Approximately 50% of surveyed Indian companies have a sustainability report evaluated separately. In the European Union (EU), 84% of companies have sustainability reporting. The reason some Indian companies do not focus on sustainability reports is that environmental reporting is voluntary. European companies develop more systematic reporting with many visual elements and colors compared to Indian companies. Indian and European annual reports contain information relating to the environment, social responsibility and economic activities.

Therefore, companies report sustainability especially for the benefits they gain. They are: material, image, new customers, innovative products and other items. The most important requirements for companies in the direction of sustainable development are (Cioca et al, 2011; Cyriac 2013; Izvercian et al., 2014; Moraru et al., 2014):

- *Ecoefficiency*: delivery of goods and services that satisfy human needs and contribute to increased quality of life; Prices are competitive, while reducing progressively ecological impacts and resources throughout the life cycle.
- *Increased resource productivity*: refers to getting more goods and services with fewer materials and energy. Knowledge flows substitute material flows to contribute to innovative products.
- *Dimensions*: dimensioning products to be in line with market demands and customer needs.
- *Reducing GHG emissions*: improving production processes so as to decrease GHG emissions. Using innovative technologies, insulation of buildings, reducing the amount of consumed energy help reduce greenhouse gases.
- *Waste management*: waste from enterprise applications can be problematic. Removing them is expensive, so a waste management program needs to be implemented so that environmental pollution to be reduced.
- *Transition to renewables*: currently we are at the end of the era of fossil fuels and a transition to renewable energy sources is necessary (the existing situation of climate change). Businesses have responded to this situation by reducing dependence on fossil fuels and increasing the use of solar, wind and other renewable energy sources.

- *Be green by selling green*: existing efforts at EU level whereby «green» companies are supported who in turn sell natural products that are healthier and less polluting.
- *Green certification*: programs that focus generally on a particular industry or sector. They establish standards for best environmental practices for these companies.
- *Respect for the environment*: use of international format for sustainability reporting. This would eliminate a number of misunderstandings. In the absence of explicit standards, companies can choose which reports and report format to use and they may change from year to year, allowing the company to hide certain aspects of their performance record. Even industry clusters were made to determine collectively standards and formats for reporting sustainability.
- *Responsibility for future actions*: it assumes the responsibility of each company for their place in future actions and strategies that they will develop. These strategies should be consistent with the principles of sustainable development.
- *Respect for society*: diverse activities in which society is sustained. It includes voluntary actions that represent a sensitive element for certain companies.

These requirements are among the directions that companies must follow in order to contribute to sustainable development. Sustainable development is a direction in which companies have to move so that future generations enjoy the same resources as today.

In accordance with the definition and implications of the concept, the goal of sustainable development is to "meet the needs of the present without compromising the ability of future generations to meet their own needs." As key forces in society, companies in all areas of activity should contribute to this goal, having an important role. In the current business environment dynamic, achieving this goal can seem more of an aspiration than a reality. With the globalization process new opportunities develop that generate prosperity and quality of life. However, these opportunities are not always available for growing human population and are accompanied by new risks that contribute to environmental instability. The existing statistics in the literature (Siew, 2015; Artene et al., 2016; Izvercian et al., 2014) show positive improvements in the lives of people worldwide, but there are situations in antithesis in which the state of the environment, poverty and famine are affecting millions of people. This contrast creates one of the most pressing dilemmas for the 21st century.

In conclusion, reporting sustainable development and contribution of each company to this approach helps reduce emissions, improve resource consumption, and improve many areas related to sustainability dimensions.

Romania is making great efforts to join global reporting approach, and the situation is improving every year. At EU level, the situation is good as long as 84% of companies report their sustainable development. EU takes action to support each country and thus supports the development of companies to improve their progress conditions (Europe Commission, 2015). Considerable efforts are made to reduce emissions (especially GHG) in rural residential and industrial areas. Thus, climate change is temperate, and the effects are reduced.

1.2.4. Integration of Corporate Social Responsibility to facilitate sustainable development

The concept of corporate social responsibility is an abstract one. In the literature there is no uniformity in the proposed definition, so there are a number of approaches. In the view of Classon et al., CSR concept includes economic, legal, ethical and philanthropic expectations that a society has in relation to an organization. In another vision, companies are perceived as human communities using social practices in order to achieve common goals (Rendtorff, and Mattsson, 2012). In the current conditions in which the focus is on sustainable development and cooperation with society, every institution has a number of concerns relating to the environment and society (Bowen, 1953; Classon, and Dahlstrőm, 2006; Yeshmin, 2012).

The initial definitions of the concept showed that CSR refers to problems: economic, political, social and ethical (Bowen, 1953). European Commission defines CSR (2001), in the Green Paper as "a concept according to which companies voluntarily decide to contribute to the attainment of a better society and a cleaner environment". In 2004, there is proposed a classification of the numerous theories by groups: instrumental, political, integrative and ethical (Garriga, and Melè, 2004). Since 2010, this concept begins to take a social aspect, so there are presented in the study of Maon et al., the differences between voluntary practices and moral obligations. Talking about the social implications, the European Commission in 2011 argues that all organizations must integrate in their activities social, environmental, ethical and human rights concerns. All these concerns need to be assessed in the strategies for development. Development strategies are developed in close liaison with stakeholders. Today, in 2014, the majority of studies (Burianová, and Paulík, 2014; Costa, and Menichini, 2013; Menichini, and Rosati, 2014) argue that CSR involves activities on the environment and society.

Researching the literature, the author has analyzed various studies published in recent years in the banking industry, situations from various countries. Based on the importance of this concept in the world, it will be presented the case of Romania and the importance of social responsibility in the banking industry.

In a study published in 2011 the correlation between social and financial performance of banks was evaluated. This study was conducted in banks from Italy, highlighting that there is not a significant link between social implications and business of banks. There negative elements of this study are not presented. The study shows that investments in CSR of the banks do not contribute to economic benefits for banks and that these activities bring a balance in the image created in the financial market (European Commission, 2011).

Lipunga in 2012, presents research results on the same direction. The study is conducted on commercial banks in Malawi. Yeshmin (2012) explores CSR concerns in private commercial banks. Annual review of the 30 banks in 2009-2010, includes information on their CSR practices. In this study, 36.67% of the banks show CSR related activities. In the same year, 2012, in Bangladesh, it was presented the study on CSR practices for the period 2010-2011. The study reveals that 100% of banks reported the implications on CSR practices (Masud, M.A.K., Hossain, 2012

The study published in 2013 highlights the growing interest of the banking industry for CSR. In the study conducted in Nigeria (Akinpelu, at al., 2013) CSR practices in banks are included in activity reports, as important elements in developing a favorable image. The study shows that most banks engage in social activities and less on the environment. The findings show that CSR approach contributes to a favorable image in the economic environment (Rendtorff, and Mattsson, 2013).

According to Lenka B. and Jiri P., in 2014, the implications of banks in CSR activities are important because the financial crisis has highlighted the need to integrate these concepts into the banking industry. From the study made the following conclusions were obtained:

- Social responsibility and banking ethics are perceived by the bank management as a tool for communicating with the public, not needed to be inserted in the bank policy,
- Most banking institutions develop such activities, being a concept addressed in a complete and complex way,
- The results from the banks involvement in social activities are quantifiable for the society.

Impact of corporate social responsibility practices on the banking industry in Romania

The purpose of this part is to explore how the corporate social responsibility (CSR) contributes to value creation in the banking industry, and during periods of financial instability. Understanding the key elements of CSR contributes to the fulfillment of the principles of this concept and to the increase of market share, profit and advancement in bank rankings. The research is based on the current situation in Romania, being developed a model of CSR applied in Romanian banks. Being in a time of economic instability, the banking industry must make efforts to maintain equilibrium in the financial market. This research can help bank managers to understand what activities to do in the benefit of customers and the community, in order to move towards a sustainable directive.

The concept of corporate social responsibility is not a new concept in the banking industry, but in the current economic situation it has become the best solution for integrating moral principles in banking activity. CSR has been defined as the voluntary integration of social and environmental concerns into the organization's decision-making process (Soana, 2011). This concept is increasingly used in the banking industry, being perceived as a tool to develop a positive image and attract new customers. Attracting new customers certainly involves a number of factors. In Romania, the banking industry has undergone changes focused mainly on credit, so they tried to find different ways to maintain equilibrium in the financial market.

The experience of implementing CSR and ethical principles in the banking industry leads to the idea that social responsibility and ethics in banking sector are seen as marketing tools for communicating with stakeholders and not an integrated part of them (European Commission, 2011).

The practices of Romanian banks

This section present the implications in CSR of eight banks listed in the first 8 places in the top 10 of Romania (European Commission, 2014). Identification data are presented for each banking institution and the national implications of CSR, Table 1.11. The study was conducted based on information published by each bank separately. In Romania it is found that there is an interdependent and complex relationship between profitability and CSR implications.

Table 1.11. Evaluation of CSR practices of banks in Romania

Headquarter	General Features	CSR Implications
Romania	Present in 22 European countries Present on 50 markets 10,000 branches >150.000 employees In Romania: more than 240 branches, >3000 employees	• In the social domain (eg. Migrations, Gift Matching, donations) • Arts and culture (publications) • Environmental protection (Cicloteque, campaigns) • In education (student scholarships).
Europa	Present in 17 European countries Present on 50 markets 7900 branches In Romania: more than 188 branches, >3000 employees	• Education (scholarships) • Culture (literary debut, art) • Environment (planting trees) • Social (elderly help) • Sports (cycling).
United Kingdom	Present in 50 countries Present on 60 markets > 230,000 employees In Romania: Over 31 branches, > 1176 employees	• Reducing the environmental impact • Active involvement of employees • Financial education • Investments in community.
Romania	Present just in Romania In Romania 710 centers, > 8700 employees	• Financial Education • Entrepreneurship • Social • Sport (sponsorship).
Austria	Presence in 17 markets Holds 3100 units > 60,000 employees In Romania: 539 centers> 6000 employees	• Romanian Arts and Culture • Financial and non-financial education • Environmental protection • Promoting sport • Supporting the disadvantaged.
Greece	Presence in 15 markets > 50,000 employees In Romania 450 branches> 3000 employees	• Social and supporting the elderly • Volunteer • Cultural education • Sport • Environment.
Holland	Present in 40 countries, 3,100 units > 125000 employees In Romania: 200 outlets,> 2000 employees	• Environment (planting, protecting) • Graduate education • Sports (cycling) • Volunteer.

From the data systematization presented in Table 1.11, it is observed that CSR practices in banks in Romania are divided into four categories: environment, education, social, art and culture. After applying this practice, the banking industry says that the activities in Romania have registered following progress:

- Improved products related to the needs of society,
- Attracting new candidates and maintaining the existing ones ,
- Increase the motivation of employees, which leads to greater creativity and innovation,

- Better promoting of the bank in competitions conducted under different campaigns,
- A good relationship with the stakeholders (the public),
- Increased customer loyalty by developing balanced banks as involvement in society practices,
- Social integration and banking reputation.

Given these benefits, the banks claim that the CSR practices improved their image and have developed a balanced image in society, but have not registered an expected level of sales for the products held.

Developing a CSR model for the banking industry

Based on the categories of practice in the banking industry in Romania, stakeholder interests, local management and the benefits from involvement in such activities, the author presents a CSR model for the banking industry in Romania, Figure 1.15.

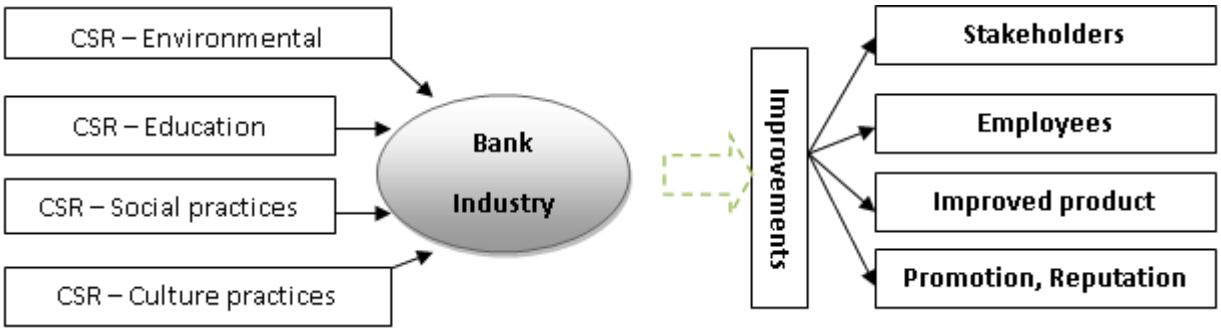


Figure 1.15. CSR model of Romanian banking industry

Note that the right side of the proposed model includes four categories of CSR practices undertaken in Romania in the banking industry. Following the completion of such practices, the bank obtained a number of benefits for its own system and in the society. This CSR practice began to be used in Romania in recent years, perhaps imposed by the current situation of financial instability.

Note that in Romania, the activities undertaken are increasingly reliant on the environment and society. Through these activities it is desired to increase the performance of the banking system because this system was directly affected by the current economic crisis.

In the current economic situation in Romania, CSR is considered an actual instrument even in the banking industry. There are a number of benefits provided for the banking institutions performing CSR, including: economic efficiency, improved company reputation, employee loyalty, communication between the banking industry and society, attracting new opportunities and increase organizational commitment.

The link between OHS and CSR

Human resource is present within any organization, so occupational health and safety (OHS) is becoming a pillar in sustainable development of the enterprise. Integrating OHS in

corporate social responsibility leads to an interesting approach that shapes and solves a number of current concerns. The integrated approach of the two concepts creates a framework for sustainable work. Through literature research there will be developed an integrated framework to facilitate the development of organizations. This framework will be developed through an analysis of EU directions in this regard and key areas of CSR and OSH in theory and practice.

This section contributes to this debate by investigating OHS initiatives within the context of CSR in organizations and asks whether CSR as a management strategy, can be expected to enhance involvement in OHS in small firms. CSR creates new perspectives on OHS, each of them creating opportunities and advantages for strengthening and further development of OHS. The integrated framework to facilitate development of organizations.

Can CSR constitute a plus value to OHS legislation and penalties directed at risks so as to elevate health and safety beyond the legal requirements?

The company develops a number of major social problems which can be solved only with the participation of the enterprises from the economic environment. Companies realize that they are part of the system in which they operate, and their contribution to social problems is imminent. Thus, the organization and the society are interconnected and cannot operate independently. As a result, there is a major interest of the companies in the social involvement and problem solving, and also in the communication and cooperation with the stakeholders (Zwetsloot, 2010). Corporate Social Responsibility (CSR) has been defined as the voluntary integration of social and environmental concerns into the organization's decision-making process (Cioca, and Moraru, 2010). CSR (Granerud, 2011) refers, also, to management strategies in which the organization deliberately works to emphasize responsible behavior towards external or internal stakeholders. The integration of this concept in health and safety at work facilitates the development of the organization and its sustainability. Occupational safety and health is a cross-disciplinary area that focuses on the safety and health of workers (Hori, 2012; Agno et al., 2014).

Corporate social responsibility and occupational health and safety

The International Organization for Standardization has defined CSR in ISO 26000 Guide (2010): "the responsibility of an organization for the impacts of its decisions and activities on society and the environment, through transparent and ethical behaviour that contributes to sustainable development, health and the welfare of society; takes into account the expectations of stakeholders; is in compliance with applicable law and consistent with international norms of behaviour; and is integrated throughout the organization and practiced in its relationships". In the literature there are a number of interpretations of this concept, but most opinions say that CSR is "the responsibility of enterprises for their impact on society" (Zwetsloot, 2010). This concept has many definitions but, in essence, it is also based on the integration of economic, social, ethical and environmental concerns in business processes.

CSR offers a number of opportunities for strengthening OHS (Jain, Leka, Zwetsloot, 2008; Rahim, 2013). Major opportunities offered by CSR:

- To achieve better integration of OHS into business processes;
- Increasing strategic importance of OHS;
- Developing and promoting innovative approaches;
- To integrate and commit new powerful stakeholders;
- Integration of safety approaches that have been developed separately until now.

CSR creates new perspectives on OHS, each of them creating opportunities and advantages for further strengthening and development of OHS. This leads to a series of challenges (Cioca, Moraru, 2010; Agno et al., 2014) such as:

- Developing strategies for improving OHS, but growing in the same time the level of innovation. These strategies are consistent with strategic management.
- Logically combining prevention and protection systems with approaches based on values (value-driven approaches).
- The involvement of powerful factors in prevention and protection systems.
- Developing an integrated approach in which health and safety at work are no longer isolated from public health and safety.
- Develop the external stakeholder vision for OHS.

For the organization, the most important reasons why it approaches the CSR concept are:

- Creation of new opportunities in the operating market;
- Better control of risk;
- Visibility and image of the organization;
- Communication and integration of stakeholder.

For organizations, the most important motives for implementing CSR are: the creation of new opportunities and better control of business risks (Zwetsloot, 2010). When we talk about risk, primarily occupational risks need to be addressed because they exist and manifest in any organization. Solving these challenges contribute to the development of the organizations and the creation of sustainable place work.

The concept of CSR can apply internally or externally. The internal integration of CSR is understood as the level of employee involvement and the content and the effects of internal oriented CSR communication and activities. External CSR includes: organization philanthropy, organization volunteerism, environmental protection, suppliers, customers, and stakeholders. The systematization of the CSR concept through the OHS is presented in Figure 1.16.

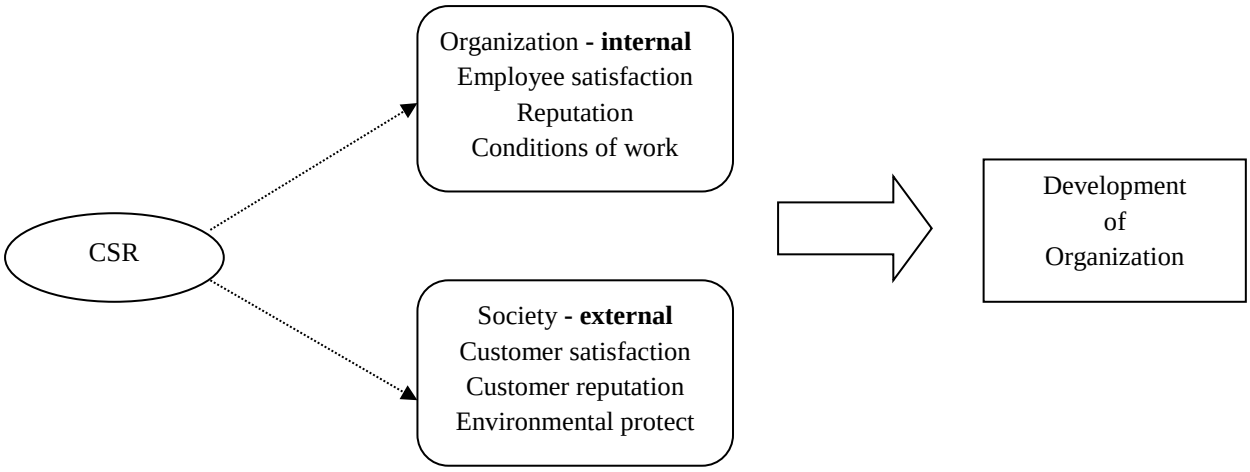


Figure 1.16. CSR model through OHS

In accordance with requirements of OHSAS 18000:2007, occupational health and safety (or occupational safety and health (OSH), or workplace health and safety (WSH)) is an area concerned with protecting the safety and health of people engaged in work or employment, Figure 1.17. OHS is important for organization because it promotes: Human Capital (knowledge, higher education, performing overtime), Structural Capital (risk management, innovation, quality and improvement) and Customer capital (trust, public image, result, customer profile) (Gogan, Draghici, Ivascu, 2014).

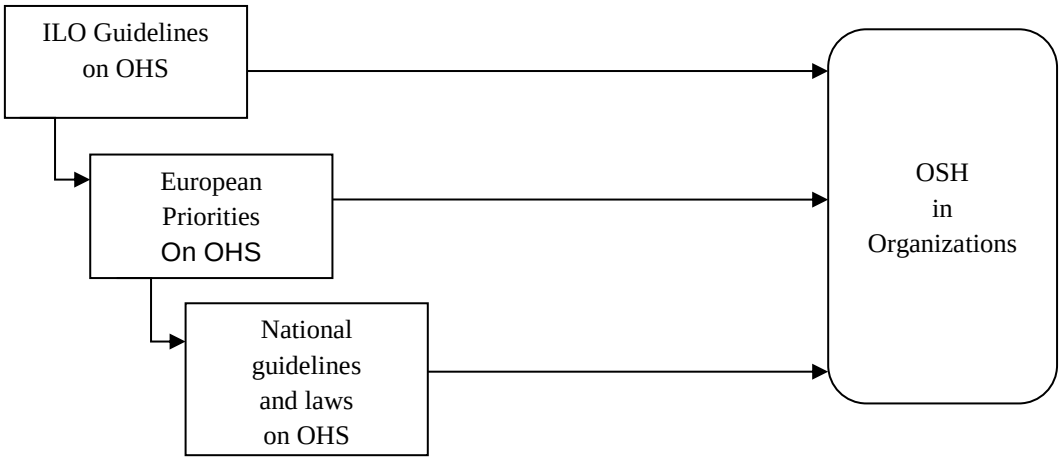


Figure 1.17. A framework for OHS management system

The integrated approach of the two concepts leads to the development of new opportunities for the organization and its development.

Integrating CSR and OHS policies and European directions

The International Labor Organization (ILO) and the World Health Organization (WHO) have advocated OHS rights of workers through conventions and declarations for decades. For example: ILO: Guidelines on occupational safety and health management systems, Occupational Safety and Health Conventions; Beijing Declaration "Occupational Health for All", et al. EU priorities regarding occupational risks are formulated in OSHA report of January

2014. Among these priorities, the need to integrate CSR is found in the organization's goals. Most significant priorities in this regard, are presented in Table 1.12.

Table 1.12. Overview of EU research priorities

Proposed EU direction	Implications
The economic dimension of occupational health and safety	Develop further the methodologies for estimating the socioeconomic costs of occupational diseases, work-related stress and violence at work.
Occupational health and safety communication and risk communication	Studies on the effects of regulatory systems, employment relations, social security systems and other contextual factors at the society–enterprise.
	Identify and characterize stakeholder and target groups.
Intervention research	Develop methodologies suitable for evaluating the effectiveness of communication in the specific context of OHS.
Demographic change — sustainable work for healthier and longer working lives	Develop CSR communication.
	Evaluate the OHS interventions at all levels.
Globalization and the changing world of work	Evaluate the association of work, health, work ability and work motivation with work participation.
	The age of the employees.
	Health inequalities and work.
	Major health problems.
Occupational health and safety research for safe new technologies.	Health management in restructuring.
	Changing organizations, new employment and work patterns, and psychosocial risks.
	Violence and harassment at work.
	Integration OHS in small enterprises.
	Using green technologies.

We can note that the OSHA European directions and actions include the concept of corporate social as one of the national and international priorities of the organizations. In Guidelines on occupational Safety and health, ILO-OSH 2001, OHS national policies must relate to: promote the implementation and integration of OSH management systems as part of the general management of an organization; promote the participation of employees and their representatives at organization level; promote collaborative and support arrangements for OHS management systems at the organization level by labour inspectorates, occupational safety and health services and other services; publishing national guidelines on the voluntary application and systematic implementation of OHS management systems in organizations and other related measures.

The integrated framework – author's approach

The role of CSR in improving OHS is one a considerable one. CSR improves the OHS internal conditions, but also provides an improvement of the image outside the organization. By integrating the two concepts in the organizations the opportunity to develop the organization

appears. Social responsibility concept is applied inside and outside the company. To the internal factors of the organization, OHS implications also intervene. Developing and creating an optimal environment for employees creates value not only for the organization but also for the business environment. Approaching OHS in the organization has internal and external effect. Involvement in social responsibility activities creates added value for the organization (communication, healthy workplaces, employee involvement in activities, interaction between employees, et al.) but especially for society (image, value, reputation, customer reputation, et al.). In conclusion, these concepts are bi-directional, developing benefits and opportunities within and outside the organization, Figure 1.18.

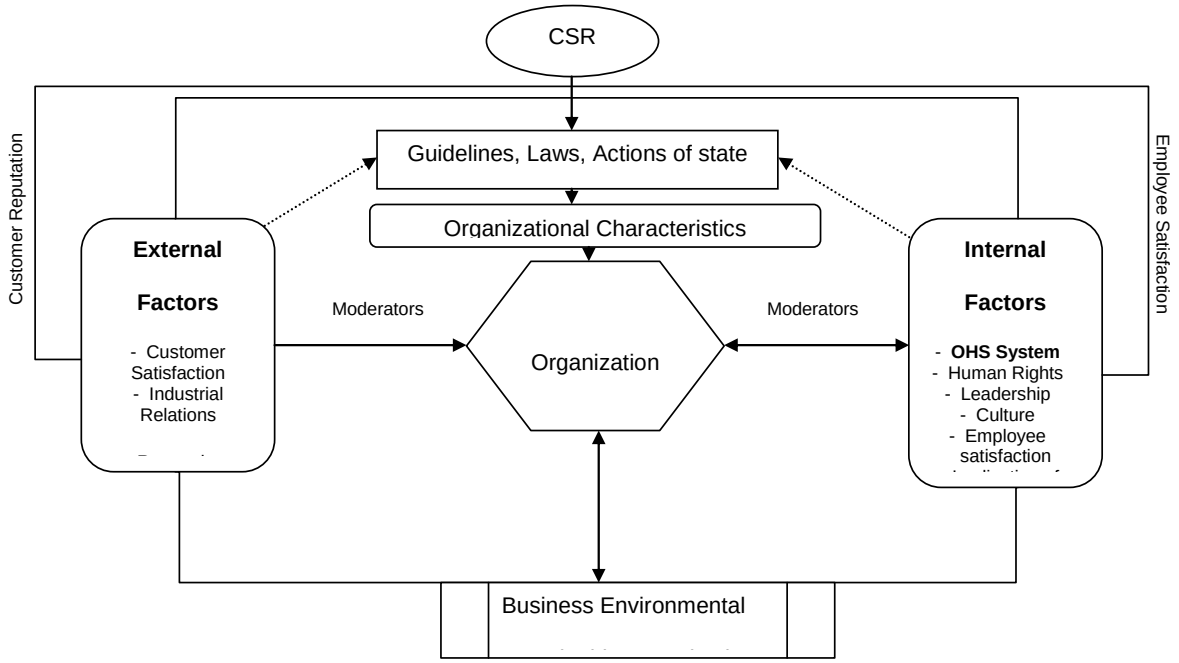


Figure 1.18. Proposed framework for integrating OHS and CS in organizations

This concept contributes to the development of the organization and its alignment with the domestic and international business requirements. Basically, these two concepts have become two national and international requirements being approached as integrate or separate in various companies.

Discussion and conclusions

CSR offers many opportunities for enhancing health and safety, but also involves a number of threats. CSR and OHS offer a number of opportunities for the organization and its sustainable development. This research presents: the integrated framework to facilitate development of organizations, analysis of global perspectives and local practices, key areas of CSR and OHS: in theory and practice, systematization of the importance of CSR in OHS and researching EU directions and Keys drivers.

Future research will focus on computerization of these solutions and testing them in various organizations. Also it is wanted a research on the tools, and associated standards of these

concepts. Following this research an informatics system will be have developed that can be implemented in different organizations.

1.2.5. The Relationship among Innovative Strategies, Corporate Environmental Responsibility, Cognitive and Hierarchical CEO

The study aims to contemplate the effectiveness of cognitive CEO, hierarchical CEO, and innovative strategies on corporate environmental responsibility (CER). Under the aegis of the theoretical perspective of stakeholder theory, our contribution is fourth fold. Firstly, the contributable concept of the cognitive CEO has been formulated through specific CEO attributes while employing the DAE statistical technique. Secondly, hierarchical CEO and its three categorizations have been formulated by analyzing listed companies' profiles. Thirdly, CER has been formulated, signifying the nine environmental attributes. Fourthly, under the patronage of the cognitive CEO and hierarchical CEO, though it has been examined that innovative strategies boost the corporate environmental responsibility, its intensity is weak. Remarkably, in comparison with the hierarchical CEO, the cognitive CEO has been substantiated to be the vigorous promoter of corporate environmental responsibility. Meanwhile, among the categorization of hierarchical CEO, only medium hierarchical CEO has affected corporate environmental responsibility. Lastly, GMM instrumental regression authenticates the reliability of empirical results.

One aspect of stakeholder holder theory inclines towards the amelioration of surroundings which is signified as an integral part of stakeholders' demand. However, the inevitable adapting of innovative strategy is necessary to confront the dynamic business environment which doesn't imply to disregard the corporate environmental responsibility. In the cognitive perspective, it is necessary to execute corporate environmental strategies which can strengthen the economic condition of the firm in the long run (Xu et al., 2020, pp. 1– 14).

Developed countries have raised the concern about the formidable trouble of environmental issue which has agitated many problems via climate changes. In this regard, the developed countries have attained vigorous resilience while executing corporate social responsible measures (Moghim, and Garna, 2019, pp. 345–354). Meanwhile, most of the countries are orientating themselves to manufacture environmentally friendly products (Shi, and Xu, 2018, pp. 187–200; Tanaka, 2015, pp. 90-103). Adhering to them, emerging countries have also endorsed corporate environmental responsibility under the aegis of the standardized procedure of corporate governance. Doubtlessly, matured corporate governance mechanism always endeavors to satisfy the demand of its stakeholders and execute such strategies which can allure the investors (Neckebrouck et al., 2018).

However, the efficiency of corporate governance relies on the prime role of the CEO. Meanwhile, the managerial ability of a CEO also augments the efficiency of investment decisions(Gan, 2019, pp. 1085–1118), which ultimately boost the firms' growth. Henceforth, specific types of CEO attributes influence the firms, growth (Kim et al., 2016, pp. 1720–1749; Ou et al., 2018, pp. 1147–1173; Park et al., 2018, pp. 919–933). Additionally, CEO attributes have been analyzed to be positively interlinked with the firms' innovative capability (de Visser & Faems, 2015, pp. 359–372). Relevantly, specific characteristics of the CEO have been

investigated, which affect the particular features of an organization such as cash holdings, innovation, and CSR activity(Chen et al., 2014, pp. 245–269; García-Sánchez & Martínez-Ferrero, 2019, pp. 542–555; Orens & Reheul, 2013, pp. 549–563; Zhang et al., 2017, pp. 585–604) but ignored the moderating role of innovative strategies.

China is a paradigm for an emerging economy, has escalated its economy through revamping industrialization engendering to exacerbate its environment (Hang et al., 2019, pp, 257–273; Peng et al., 2018, pp.181–189). In this regard, China launched an antipollution campaign to mitigate the intensity of pollutants and effluents so that the ecology of the environment may be ameliorated. To achieve this goal, environmental taxes have been levied on enterprises (Xu et al., 2020, pp. 1– 14). Additionally, China has also compelled its listed companies to unveil environmental measures. Reciprocally, the repercussion of a decline in shareholder value owing to adopting green environmental strategies has caused panic among Chinese firms (Lyon et al., 2013, pp. 1–8). Consequently, the Chinese government has to be lenient for the Chinese firms while curtailing the environmental problem (Zou et al., 2018, pp. 40–52). Despite this obstacle, specific attributes of CEOs among Chinese firms have been analyzed to be positively related to environmental reporting (Shahab et al., 2018, pp. 1635–1652). However, they have ignored the particular CEO characteristics which can invigorate the cognitive ability while being conducive for corporate environmental responsibility.

Distinguishably, Chinese listed firms are segregated into SOEs and non-SOEs while having excessive control of the government. Significantly, CEOs are answerable in case of poor performance, and they are forcefully turned over (Zhu et al., 2016). Remarkably, the hierarchical structure within the Chinese firm indicates authority and prestige. Therefore, hierarchical positioning of board members is also allocated according to seniority(He, and Huang, 2011). In case of forceful turnover, abrupt selection of board member is executed among hierarchical ladder (Shah, 2019) which escalate the performance. Despite, they haven't demonstrated the impact of hierarchical CEO on corporate environmental responsibility under the effectiveness of innovative strategies.

This study has contributed in quadruplets directions. Firstly, the cognitive CEO has been formulated while executing DAE statistical techniques. Secondly, hierarchical CEO and its three categorizations (low, medium and high) have been formulated via analyzing the companies' profile. Thirdly, the corporate environmental responsibility index has also been formulated by contemplating the nine attributes related to the environmental safety. Fourthly, innovative strategy input and output have been analyzed as a moderator between cognitive CEO, hierarchical CEO and corporate environmental responsibility. Lastly, the GMM instrumental regression technique has been executed to authenticate the reliability of empirical results.

Theoretical Background and Hypothesis Formulation

Corporate Environmental Responsibility, Cognition, Hierarchy and Stakeholder Theory Perspective

Doubtlessly, the firms' orientation towards corporate environmental responsibility does augment the firms' reputation (Qiu et al., 2016, pp. 102-116.), which serves as an intangible asset. Consequently, stakeholders attain the benefits through the elevated firms' reputation. Conclusively, one aspect of stakeholder theory enunciates that stakeholders of the company such as company management, employees, company suppliers and its surroundings should be benefitted and secured (Andries & Stephan, 2019, pp.3585). Therefore, it is not only an ethical responsibility of the firms but also the demand of stakeholders to secure the environment deliberately. Intuitively, the stakeholder pressure is also a vigorous cause which compels the corporate governance to adopt proactive environmental strategies(Schmitz et al., 2019, pp. 281-308). Henceforth, the disclosure of corporate environmental attributes within the corporate social responsibility reports signifies the intensity of orientation of firms towards social and environmental responsibility. Additionally, one salient feature of stakeholder theory recommends adopting innovative strategies(Liao & Tsai, 2019, pp. 316– 326) which will assist the firms in producing environmental friendly products. Most significantly, stakeholder theory also suggests the significance to the top management team (TMT), which is among the stakeholders and who launch strategies either innovative or formal to escalate the firms' profitability.

According to the social cognition theory, individual characteristics can influence the firms' growth asymmetrically under the aegis of environmental factors (Staples & Webster, 2007, pp. 60–97). Particularly, cognitive psychology has revealed that cognition regularizes brain functionality, which assists the individual to make the optimal decision (Barsalou, 1992). Categorically, cognition affects the individual' investment decision (Lee et al., 2020, pp. 86– 107). Hence, it can be deduced that the cognitive ability of a CEO can orientate him or her towards innovative strategies via investing in R&D.

Emphatically, if a manager or a CEO adopts cognitive strategies, he or she can escalate the performance vigorously (Torrence & Connelly, 2019). Convincingly, cognition intensifies the hidden innovative capabilities of employees, which augments the motivation level and refurbishing the working styles(X. Chen et al., 2019, pp. 671–694). Meanwhile, the cognitive ability of managers is interlinked with environmental strategies, which ultimately invigorates the firms' innovative ability(Yang et al., 2019, pp. 1147–1161). Additionally, the cognitive adaptability of the CEO also signifies his or her innovative capability (Moore & Wang, 2017,pp. 120–143) which can be rejuvenated through the involvement of every board member in hierarchy.

Arguably, the role of the organizational hierarchy can also be elucidated via a stakeholder perspective. Convincingly, hierarchy boosts the firms' performance(He & Huang, 2011, pp. 1119–1139). Additionally, hierarchical disturbance among CEO succession has been witnessed to be positively interlinked with innovative strategies (Sarfraz et al., 2019). On the contrary, hierarchical positioning disintegrates board members into low, medium and high level. Under the umbrella of social identity theory (Hogg & Terry, 2000, pp. 121–140), every board member endeavour to elevate his hierarchical positioning. Particularly, the rewards intensify the intensity of motivation which is interlinked with hierarchical positioning. Reasonably, medium level board member suffers from a sense of vulnerability which acts as a catalyst for boosting their enthusiasm to work diligently (Shah et al., 2019). Ultimately, whenever medium level

board members are given the opportunity to lead as a CEO, they orientate towards innovative strategies and endorse to disclose corporate environmental responsibility measures.

Hence, keeping these arguments in the same vein, it is manifested that cognitive CEO and hierarchical CEO are orientated towards innovative strategies which ultimately invigorate corporate environmental responsibility.

Corporate Environmental Responsibility and Cognitive CEO

The extant literature accentuates that corporate governance does invigorate the environmental performance, social performance and environmental disclosure (Lagasio & Cucari, 2019, pp. 701–711). Doubtlessly, environmental performance and organizational performance are positively interlinked (Hang et al., 2019, pp. 257–273). Meanwhile, it has been analyzed that gender role also intensifies the corporate environmental performance (Elmagrhi et al., 2018, pp. 206-220). Similarly, board diversity having specific characteristics not only escalates the environmental performance but also takes the initiative to augment the environmental strategies (García-Sánchez & Martínez-Ferrero, 2019, pp. 542–555) The prior study has also examined that specific CEO attributes invigorate corporate environmental responsibility (Zou et al., 2018, pp. 40–52). In this regard, (Cho et al., 2019, pp. 159–169). have already demonstrated that CEO specific attributes have a positive relationship with corporate environmental responsibility but disregarded the psychological aspect which is interlinked with CEO cognition.

The cognitive ability reinforces to perceive the circumstances before its occurrence. It has been identified that cognition assists the top management while making an abrupt decision (Joseph & Gaba, 2020, pp. 267–302). Conclusively, the potential motivation level also consolidates the cognitive ability, which ultimately props up while confronting the dynamic environment (Shepherd et al., 2018, pp. 51–103). Hence, the cognitive perspective of the CEO orientates him or her towards corporate environmental responsibility(Yang et al., 2019, pp. 1147–1161).

Moreover, cognitive ability also rejuvenates the innovative capabilities which are necessary for firms' performance. Similarly, some study also witnesses the significance of cognitive ability among the upper echelon, which invigorates the dynamic capabilities while escalating the sustainable growth (Helfat & Peteraf, 2015, pp. 831–850). Further, cognition among top management team enforces them to launch such strategies which are ultimately conducive for firms' growth (Bromiley & Rau, 2016, pp. 174–202). Meanwhile, in the context of corporate environmental responsibility, the cognition of a CEO enables him to decide on environmental protection through the implementation of technologies for recycling of waste materials (Gröschl et al., 2019, pp. 741–762; Hart, 1995, pp. 986–1014). Certainly, the cognitive ability of a CEO is necessary while curtailing the unpredictability of environmental change(Yang et al., 2019, pp. 1147–1161).

A recent study has demonstrated that CEO tenure, education promotes the environmental responsibility disclosure but neglected the effectiveness of the cognitive CEO on corporate environmental responsibility (Lewis et al., 2014, pp. 712–722). (Liu et al., 2018, pp. 789–816) have examined that CEO attributes influence the cognitive ability of the CEO, which is ultimately beneficial for firms' growth. However, H. Li (2020) have elucidated the positive

impact of cognitive CEO on CSR activity and performance of Chinese SMEs. Henceforth, our first hypothesis can proceed as follow

Hypothesis 1 (H1): Cognitive CEO invigorates the corporate environmental responsibility

Under the aegis of institutional theory, institutional pressure has been substantiated as a vigorous vehicle that enforces firms to adopt corporate environmental responsibility (Gao et al., 2019, pp. 6588.). Meanwhile, another side of the mirror under this institutional pressure leads the organizations to be benefitted through economically and ethical rewards (Jamali, 2010,pp. 617–640; Kraatz & Moore, 2002, pp. 120–143). However, paradox cognitive theory conceives that there is a contradiction between the protection of environmental strategies and the economic advantages of the firms(K. U. Shah et al., 2016, pp. 237–253). On the contrary, paradox cognition theory also enunciates that firms can adopt environmental protection measures, which will ultimately boost firms' performance(Gao et al., 2019, pp. 6588). Despite these point of views, the cognitive ability of a CEO is quite significant for making decision-related to corporate social responsibility. Though CEO specific attributes, not only escalates the firms' performance but also intertwined with corporate social responsibility(Li et al., 2020). However, it is the discretionary power of the CEO whether to adopt corporate social responsibility, environmental and innovative strategies, or not? Implicatively, cognition among top management team can lead them to adopt innovative strategies (Raffaelli et al., 2019, pp. 1013–1039). Similarly, CEO cognition always assists him or her in perceiving the significance of a proactive environmental approach, which ultimately orientates him or her towards innovative strategies (Yang et al., 2019, pp. 1147–1161). Additionally, innovative strategy as a moderator elevates the firms' value along with orientation towards corporate environmental responsibility (Li et al., 2020, pp. 1045–1055). Henceforth, it is still required to contemplate the moderating role of innovative strategies between cognitive CEO and corporate environmental responsibilities, which this study has elucidated comprehensively. To encapsulate, cognitive CEO having specific characteristics like, maturity, education, tacit knowledge, and goodwill does boost the CSR activity (H. Li et al., 2020) and firms which adopt corporate environmental responsibility are also orientated towards innovative strategies which accelerate the firms' growth (Li et al., 2020, pp. 1045–1055). Arguably, we can proceed towards our next hypotheses

Hypothesis 2 (H2): Innovative strategy input as a moderator invigorates the corporate environmental responsibility under the patronage of cognitive CEO

Hypothesis 3 (H3): Innovative strategy output as a moderator augments the corporate environmental responsibility under the aegis of cognitive CEO

Hierarchical CEO, Innovative Strategy and CER among Chinese Firms

Prior study has revealed that hierarchy among board members escalates the firms' performance (He & Huang, 2011, pp. 1119–1139). Among Chinese firms, hierarchical position in the hierarchical ladder indicates the authority, seniority and status (Zhu et al., 2016, pp. 262–

279). Meanwhile, among the company's profile, it has been observed that the allocation of independent directors in the hierarchical ladder is always kept higher. In this regards, Chinese firms can be considered as hierarchical firms where CEO plays a pivotal role. However, the CEO is bound to perform splendidly; otherwise, he or she can be forcefully turned over. The extant literature has observed excessive forceful turnover among Chinese SOE s(Hu & Leung, 2012, pp. 235–262). Being an amalgamation of two types of firms (SOEs and Non-SOEs), Chinese CEOs have political interconnection with the government (Wu et al., 2018, pp. 169–180). Their prime objective is to promote government agenda in forms allocating the public in an organization and to proceed political campaign.

Most significantly, Chinese firms are transitioning from imitating to innovation(Zhan et al., 2020). In this regards, following the innovative strategy, a lot of investment has been observed in the R&D department(Yang et al., 2019, pp. 1147–1161). Meanwhile, a lot of firms have attained the number of patents to boost the firms' reputation. Despite that, the role of the CEO is highly significant for implementing innovative strategies among Chinese firms. A recent study has witnessed that even force full succession via hierarchical fluctuation does boost the innovative strategy among Chinese firms (Sarfraz et al., 2019). Moreover, (H. Li et al., 2020) has unveiled that CEO having specific attributes strengthen the performance and invigorates the CSR activity but neglected the role of innovative strategy as a moderator which can augment the corporate environmental responsibility. Though (Cho et al., 2019, pp. 159–169) have emphasized the positive relation between CEO attributes and corporate environmental responsibility but ignored the effectiveness of hierarchical CEO on CER.

Argumentatively, hierarchy signifies the hierarchical rank, but it differentiates the board members into three categories (low medium and high) (He & Huang, 2011, pp. 1119–1139). According to (Sarfraz et al., 2019), board members belonging to medium level confront the vulnerability and always endeavor to perform marvelously. Henceforth, in case of forceful turnover, the abrupt appointment of a medium level board member as a CEO will compel him or her to launch such strategies which are conducive for firms' profitability. Relevantly, (Sarfraz et al., 2019) have revealed that forceful appointed CEO via medium level board member invigorate the firms' innovative strategy. Meanwhile, Shah (2020) have signified the specific forceful appointment of CEO is conducive for firms' growth. Therefore, whenever, a hierarchical CEO is appointed, he or she must concentrate on corporate environmental responsibility. Keeping these views, our hypotheses are proceeded as follow

Hypothesis 4 (H4): Hierarchical CEO and medium hierarchical CEO boost the CER activity

Hypothesis 5 (H5): Both innovative strategy input and output augment the CER activity under the patronage of hierarchical CEO

Hypothesis 6 (H6): Both innovative strategy input and output augment the CER activity under the aegis of medium hierarchical CEO

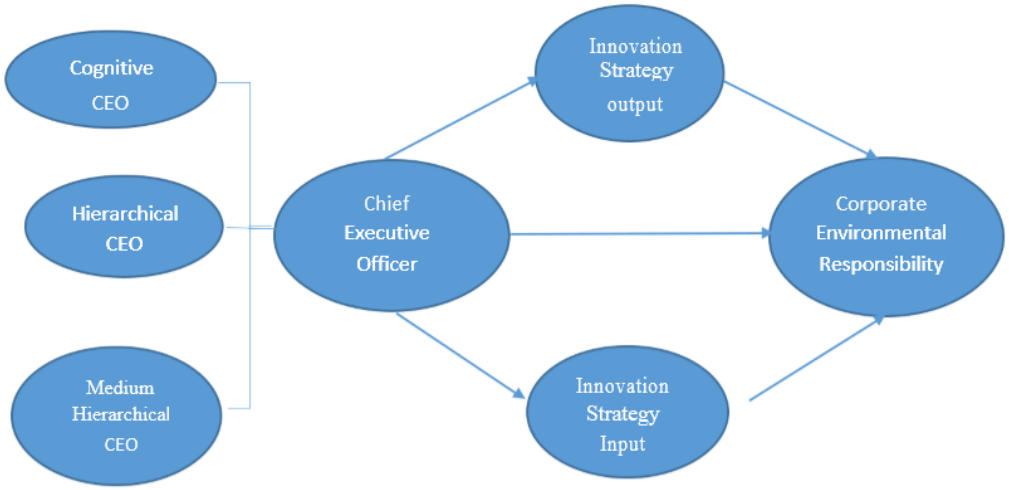


Figure 1.19. Theoretical framework

Data and Empirical Model

Data Accumulation and Measures

Data has been accumulated for the years 2015-2019 for the 1058 listed Chinese firms on Shenzhen and Shanghai Stock Exchanges. The authenticated CSMAR and WIND data resources have been endorsed for collecting the data. Our independent variable cognitive CEO has been formulated while executing the DAE technique (H. Li et al., 2020). Meanwhile, the dependent variable CER index has been formulated while contemplating the nine attributes in Table 1.13.

$$CERI_{i,t} = \frac{\sum_{i=1}^{9} Z_{i,t}}{N} \quad (1)$$

Equation (1) illustrates the formulation of the corporate environmental responsibility[1] index while contemplating nine attributes (Xu et al., 2020, pp. 1-14).

Table 1.13. Formulation of Corporate Environmental Responsibility Index

	Attributes	Measurement
1	Whether a company discloses environmental protection policies, objectives, and affects	Yes=1, No=0
2	Whether a company discloses the company's total annual resource consumption	Yes=1, No=0
3	Whether a company discloses the company's environmental protection investment and environmental, technological development	Yes=1, No=0
4	Whether a company types quantity, concentration, and destination of pollutants discharged	Yes=1, No=0
5	Whether a company has constructed and operated its environmental	Yes=1, No=0

[1] According to (Chen et al., 2018) Shanghai stock exchange has provided guidelines for unveiling the corporate environmental responsibility reports.

	protection facilities	
6	Whether a company discloses the waste treatment, disposal, and waste products in the production process	Yes=1, No=0
7	Whether a company has voluntarily signed the agreement with the environmental protection department to ameliorate the environmental behaviour	Yes=1, No=0
8	Whether a company has been rewarded by the environmental protection department	Yes=1, No=0
9	Whether a company has disclosed any other environmental information Voluntarily	Yes=1, No=0

Meanwhile, the Cognitive CEO has been formulated via the DAE technique. Mathematically, the cognitive CEO is written as follow

$$CGCEO_{i,t} = \sum_{\vartheta=1}^{m} k_{\vartheta} x_{\vartheta l} \Big/ \sum_{\vartheta=1}^{p} q_{\vartheta} y_{\vartheta l} \quad \text{where } \vartheta = 1,2, \dots \dots, n \qquad (2)$$

In equation (2), there are "p" inputs and "m" outputs. In equation (2), the output is intangible assets, whereas inputs are tacit knowledge (number of meetings attended by CEO and foreign exposure[2]), goodwill, CEO tenure, CEO age, and CEO education. The input variables substantiating the attainment of tacit and specific knowledge, which boost the cognitive ability.

Adhering to the extant literature, specific control variables have been endorsed, demonstrating the relation between CEO attributes and CER index(Shahab et al., 2018, pp. 1635–1652). In this regard, EPS (earnings per share) and LEV (Leverage) have been preferred variables that indicate the firms' growth (H. Li et al., 2020). Additionally, total employees (LNEMP), total assets (LNTA), and firms age (Fage) (Xu et al., 2020, pp. 1– 14) are interlinked with organizational innovation and CSR activity. The extant literature witnesses that matured firms adopt innovative strategies (Yang et al., 2019, pp. 1147–1161). Similarly, firms having large size also have a positive relationship with CSR activity.

Meanwhile, the variables, "Dual" and "SOE" have been endorsed due to the distinguishing characteristics of Chinese firms. Specifically, among Chinese firms, SOEs are alleged to be controlled firms, but their market capitalization is enormous. Additionally, Chinese CEOs are also under the strict surveillance of government, but CEOs of Chinese firms also capture dual authority, which is why the variable "Dual" has been embedded in the panel regression (Sarfraz et al., 2019).

[2] Foreign exposure has been defined as job or working experience in foreign has been defined as a dummy variable (Shahab et al., 2019)

Empirical Models

The panel regression technique has been endorsed to evaluate the effectiveness of cognitive CEO and moderating role of innovative strategy. After the confirmation of the presence of endogeneity via executing lagged variable regression, we have directly interpreted the results of GMM instrumental regression, which are reliable to be interpreted (Larcker & Rusticus, 2010, pp. 186–205). The instrumental variable, "specific cognitive CEO,"[3] has been endorsed to execute the GMM instrumental regression. Mathematically panel regression models are represented as follow

$$CERI_{i,t} = \varphi_0 + \varphi_{1i,t}LNCGCEO_{i,t} + \varphi_{2i,t}EPS_{i,t} + \varphi_{3i,t}LEV_{i,t} + \varphi_{4i,t}LNEMP_{i,t} + \varphi_{5i,t}LNTA_{i,t} + \varphi_{6i,t}SOE_{i,t} + \varphi_{7i,t}IDIR_{i,t} + \varphi_{8i,t}Dual_{i,t} + \varphi_{9i,t}Fage_{i,t} + \mu Industry + \rho\, Year + \varepsilon_{i,t} \quad (3)$$

$$CERI_{i,t} = \varphi_0 + \varphi_{1i,t}(LNCGCEO_{i,t} * INVSIP_{i,t}) + \varphi_{2i,t}EPS_{i,t} + \varphi_{3i,t}LEV_{i,t} + \varphi_{4i,t}LNEMP_{i,t} + \varphi_{5i,t}LNTA_{i,t} + \varphi_{6i,t}SOE_{i,t} + \varphi_{7i,t}IDIR_{i,t} + \varphi_{8i,t}Dual_{i,t} + \varphi_{9i,t}Fage_{i,t} + \mu Industry + \rho\, Year + \varepsilon_{i,t} \quad (4)$$

$$CERI_{i,t} = \varphi_0 + \varphi_{1i,t}(LNCGCEO_{i,t} * INVSOP_{i,t}) + \varphi_{2i,t}EPS_{i,t} + \varphi_{3i,t}LEV_{i,t} + \varphi_{4i,t}LNEMP_{i,t} + \varphi_{5i,t}LNTA_{i,t} + \varphi_{6i,t}SOE_{i,t} + \varphi_{7i,t}IDIR_{i,t} + \varphi_{8i,t}Dual_{i,t} + \varphi_{9i,t}Fage_{i,t} + \mu Industry + \rho\, Year + \varepsilon_{i,t} \quad (5)$$

In equations (3)- (5), "$LNCGCEO_{i,t}$", "$\mu Industry$ and $\rho\, Year$" represent the logarithm of cognitive CEO, industry dummy and year dummy respectively. Moreover, the interaction terms, "($LNCGCEO_{i,t} * INVSIP_{i,t}$) and ($LNCGCEO_{i,t} * INVSOP_{i,t}$) indicate the innovative strategy moderators (innovative strategy input and innovative strategy output), which have been measured via proxies (taking the logarithm of R&D expenditures and number of patents, respectively) (Sarfraz et al., 2019).

Empirical Results

GMM instrumental regression has been executed. The respective panel regression has already been mentioned in empirical models (equations (3) - (5)). Table 1.14 describes the descriptive statistics, which illustrates the number of observations, mean, and standard

[3] (Li et al., 2020) have endorsed the "specific cognitive CEO" while embedding CEO compensation in DAE formula. Moreover, CEO compensation is directly interconnected with firms' performance and also it intensifies the motivation of CEO which can assist him or her in taking the absolute decision.

deviation. Significantly, Table 1.14 has also revealed that all variables have an acceptable standard deviation.

Table 1.14. Descriptive Statistics

Variable	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
CERI	5289	.6131448	.1207559	.1538462	1
LNCGCEO	4663	12.61095	2.355947	-8.18696	20.97182
HCEO	5273	.0948227	.2929976	0	1
EPS	5287	.3200184	.8889696	4.859921	42.43205
LEV	5287	.4560903	.3528418	.007969	11.50969
LNTA	5285	22.04916	1.237889	14.94164	28.71384
LNEMP	5285	7.637925	1.236736	1.609438	11.7313
Dual	5285	.2675464	.442722	0	1
SOE	5289	.3505389	.4771838	0	1
IDIR	5289	8.672528	1.72827	3	15
Fage	5289	10.26413	3.541356	4	27
INVSIP	5202	17.56211	1.427705	5.09375	25.02517
INVSOP	4097	3.676066	1.495125	0	10.1133

In Table 1.14, the variables "LNCGCEO" (logarithm of cognitive CEO), "INVSIP" (logarithm of R&D), and "INVSOP" (Logarithm of patents) have less number of observations due to taking the logarithm of "0" value which has caused to skip the number of observations. Meanwhile, the remnant variables such as "EPS," "CERI," "HCEO", "LEV," "LNTA," "LNEMP," "Dual," "IDIR," "Fage" (earnings per share, hierarchical CEO, corporate environmental responsibility Index, leverage, total assets, number of employees, number of independent directors and firm age respectively) have the almost same number of observations.

Table 1.15 indicates the results of GMM instrumental regression for the cognitive CEO, which affects the CER ratio positively. The first row of Table 3 signifies that "LNCGCEO" is positively significant (coefficients values are 0.203* and 0.204*, respectively). Additionally, independent directors (IDIR) are positively significant for CER index (0.212*, 0.198*, and 0.207*, respectively). Arguably, independent directors endeavor to orientate the CEOs to disclose the CER reports so that a positive image of an organization may be attained among all stakeholders. Moreover, state-owned enterprises (SOE) are positively significant, which elucidates that SOEs prefer CER activities emphatically. Lastly, Firm age (Fage) is highly significant, which suggests that matured firms are inclined towards adopting CER actively just to elevate their image and to sustain their growth.

Table 1.15. GMM Instrumental Regression for Cognitive CEO and CSR ratio

	(1)	(2)	(3)
VARIABLES	CERI	CERI	CERI
LNCGCEO	0.203*	0.203*	0.204*

	(0.115)	(0.114)	(0.114)
EPS	-0.173	-0.171	-0.169
	(0.156)	(0.156)	(0.156)
LEV	0.169	0.183	0.202
	(0.436)	(0.436)	(0.438)
LNTA	0.252	0.253	0.200
	(0.184)	(0.183)	(0.149)
LNEMP	-0.0996	-0.0949	
	(0.175)	(0.175)	
IDIR	0.212*	0.198*	0.207*
	(0.110)	(0.108)	(0.106)
Dual	-0.240	-0.224	-0.229
	(0.404)	(0.404)	(0.403)
SOE	0.0109**	0.0109**	0.0108**
	(0.00495)	(0.00493)	(0.00489)
Fage	0.496***	0.492***	0.493***
	(0.0386)	(0.0383)	(0.0383)
Industry Dummy	Inserted	Inserted	Inserted
Year Dummy	Inserted	Inserted	Inserted
Constant	48.92**	48.92**	49.35**
	(4.042)	(4.026)	(3.881)
Observations	4,584	4,595	4,598
R-squared	0.056	0.055	0.054

Robust standard errors in parentheses

**** p<0.01, ** p<0.05, * p<0.1*

Table 1.15 has indicated that the cognitive CEO (LNCGCEO) is positively significant for the corporate environmental responsibility index (1st row of Table 1.14). Moreover, the independent directors (IDIR) have also boosted the CER ratio (7th row of Table 1.14). Additionally, "SOE" is positively significant for the CERI (9th row of table 2). Similarly, "Fage" is highly significant for CERI (8th row of Table 1.14The remaining variables, "EPS," "LEV," "LNTA," "LNEMP," "Dual" are insignificant.

Table 1.16 identifies that innovative strategy input as a moderator augments the CER ratio. However, its coefficient values (0.0117*,0.0118*, and 0.0115*, respectively) are less as compared to the values of the coefficients of cognitive CEO (0.203* and 0.204*). Argumentatively, cognitive CEOs are least orientated towards allocating funds in the R& D sector because they emphasize on their personal experience to utilize the organizational resources so that maximum advantages may be attained. Further, the variables SOE, IDIR, and Fage have shown positive relation with the CER index (as represented by the Table 1.14).

Table 1.16. GMM Instrumental regression for innovative strategy input as a moderator

	(1)	(2)	(3)
VARIABLES	CERI	CERI	CERI
LNCGCEO*INSVIP	0.0117*	0.0118*	0.0115*
	(0.00678)	(0.00675)	(0.00668)
EPS	-0.153	-0.150	-0.145
	(0.157)	(0.158)	(0.157)
LEV	0.139	0.172	0.139
	(0.441)	(0.444)	(0.445)
LNTA	0.242	0.161	0.158
	(0.187)	(0.155)	(0.154)
LNEMP	-0.153		
	(0.179)		
Dual	-0.0709	-0.0816	
	(0.413)	(0.413)	
SOE	0.0106**	0.0106**	0.0106**
	(0.00495)	(0.00493)	(0.00488)
IDIR	0.204*	0.189*	0.192*
	(0.110)	(0.109)	(0.107)
Fage	0.493***	0.494***	0.492***
	(0.0386)	(0.0384)	(0.0382)
Industry Dummy	Inserted	Inserted	Inserted
Year Dummy	Inserted	Inserted	Inserted
Constant	47.70**	48.42**	48.52**
	(4.186)	(4.027)	(3.995)
Observations	4,515	4,518	4,570
R-squared	0.057	0.057	0.057

Robust standard errors in parentheses

**** p<0.01, ** p<0.05, * p<0.1*

Table 1.16 has unveiled the positively significant value of the moderator innovative strategy input (CGCEO*INVSIP) (1st row of table 3). Meanwhile, SOE has shown positive significance for CERI. Additionally, independent directors (IDIR) and Firm age (Fage) are positively significant for CER disclosure (same results as revealed by table 3).

Table 1.17 has shown that innovative strategy output as a moderator also boosts the CER disclosure. Significantly, the values of the coefficients of the interaction term (LNCGCEO*INVSOP) are 0.0737*, 0.0731*, and 0.0709*, respectively. Convincingly, the higher values of innovative strategy output (as a moderator) signifies that firms having more number of patents endorse to disclose their CER. Logically, these results are satisfied because innovative strategy output authenticates the splendid future performance of the firms while confronting the dynamic business environment emphatically. Moreover, the remaining variables (SOE, Fage, and IDIR) have also indicated a positive relationship with the CER index.

Table 1.17. GMM Instrumental Regression for the Moderator Innovative strategy output

	(1)	(2)	(3)
VARIABLES	CERI	CERI	CERI
LNCGCEO*INVSOP	0.0737*	0.0731*	0.0709*
	(0.0425)	(0.0423)	(0.0415)
EPS	-0.0748	-0.0714	-0.0708
	(0.148)	(0.150)	(0.150)
LEV	0.578	0.624	0.555
	(0.601)	(0.608)	(0.602)
LNTA	0.177	0.0510	0.0580
	(0.212)	(0.178)	(0.177)
LNEMP	-0.232		
	(0.197)		
IDIR	0.321***	0.297**	0.307***
	(0.121)	(0.120)	(0.117)
Dual	-0.0501	-0.0730	
	(0.479)	(0.477)	
SOE	0.0190**	0.0183**	0.0179**
	(0.00782)	(0.00787)	(0.00774)
Fage	0.521***	0.523***	0.519***
	(0.0444)	(0.0439)	(0.0430)
Industry $_{Dummy}$	Inserted	Inserted	Inserted
Year $_{Dummy}$	Inserted	Inserted	Inserted
Constant	47.54**	48.73**	48.62**
	(5.107)	(4.977)	(4.888)
Observations	3,547	3,550	3,598
R-squared	0.046	0.045	0.046

Robust standard errors in parentheses
**** p<0.01, ** p<0.05, * p<0.1*

Table 1.17 has unveiled that the moderator innovative strategy output is positively significant for the CER index. The first row of Table 1.16 indicates the coefficient values of innovative strategy output (LNCGCEO*INVSOP), are "0.0737*", "0.0731*", "0.0709*" respectively. Similarly, the variables "SOE," "IDIR," and "Fage" are positively significant for CERI, respectively. The remaining variables, "Dual," "EPS," "LEV," "LNTA," "LNEMP" are all insignificant (as represented by previous tables).

Hierarchical CEO, Innovative Strategies and Corporate Environmental Responsibility

Chinses firms are distinguished due to having specific characteristics like the influential role of government through ownership structure and categorization of enterprises (SOEs and Non-SOEs). Most significantly, CEOs among Chinese firms either belonging to SOEs or Non-SOEs are politically linked while promoting government agenda (Wu et al., 2018, pp. 169–180). In this regards, the board members always endeavor to perform splendidly for their elevation within their hierarchical position. In China, hierarchical positioning indicates power, status and authority, which is allocated according to seniority, experience and political connection(Zhu et al., 2016,pp. 262–279). Chinese firms are being alleged for turning over CEO forcefully during

the aggravated performance (Hu & Leung, 2012,pp. 235–262) and predecessor CEO is appointed while selecting through the hierarchical ladder. The categorization of the hierarchical ladder can be categorized into low, medium and high level. Through analyzing the company' profile, hierarchical CEO has been formulated (Sarfraz, et al., 2019). Additionally, low, medium and high hierarchical CEO has also been formulated. Significantly, hierarchical CEO is a dummy variable which has appointed while neglecting his senior board member during internal succession. Mathematically hierarchical CEO and its three types have been represented as follow

$$HCEO_{i,t} = \begin{cases} 1 & if\ \ IN_{succ} > 0, \quad HPHL_{i,t-1} > 2 \\ 0 & other\ wise \end{cases} \tag{6}$$

$$LHCEO_{i,t} = \begin{cases} 1 & if\ \ IN_{succ} > 0, \quad HPHL_{i,t-1} \epsilon\ UI_{HP} \\ 0 & other\ wise \end{cases} \tag{7}$$

$$MHCEO_{i,t} = \begin{cases} 1 & if\ \ IN_{succ} > 0, \quad UI_{HP} < HPHL_{i,t-1} < LI_{HP} \\ 0 & other\ wise \end{cases} \tag{9}$$

$$HHCEO_{i,t} = \begin{cases} 1 & if\ \ IN_{succ} > 0, \quad HPHL_{i,t-1} \epsilon\ LI_{HP} \\ 0 & otherwise \end{cases} \tag{10}$$

Equation (6) illustrates the formulation of hierarchical CEO whose value is equal to "1" if the internal succession occurs ($IN_{succ} > 0$) and his or her hierarchical position in the hierarchical ladder ($HPHL_{i,t-1}$) was greater than two before appointment ($HPHL_{i,t-1} > 2$). Additionally, equation (7)- (9) represents low hierarchical CEO, medium hierarchical CEO and high hierarchical CEO, respectively. Equation (7) elaborates that low hierarchical CEO ($LHCEO_{i,t}$) will be assigned the value "1" if the internal succession occurs and a novel CEO is appointed while selecting through the upper interval of hierarchical position (UI_{HP}). Similarly, equation (9) illustrates that medium hierarchical CEO ($MHCEO_{i,t}$) is considered if, during international succession, he or she has been appointed while selecting through medium hierarchical interval ($UI_{HP} < HPHL_{i,t-1} < LI_{HP}$). Lastly, equation (10) accentuates high hierarchical CEO ($HHCEO_{i,t}$) which has been assigned the value "1" whenever an internal succession is executed and the novel CEO has been selected through the lower interval in hierarchical position (LI_{HP}).

For contemplating the impact of hierarchical CEO and all its three types (low medium and high), GMM instrumental regression has been executed. The instrumental variable "Total hierarchical position" has been embedded in the instrumental regression to eradicate the endogeneity problem. We have added new control variables for elucidating the effectiveness of hierarchical CEO. CEO age and CEO education have been embedded in the panel regression. Mathematically our empirical models are written as follow

$$CERI_{i,t} = \varphi_0 + \varphi_{1i,t} HCEO_{i,t} + \varphi_{2i,t} EPS_{i,t} + \varphi_{3i,t} LEV_{i,t} + \varphi_{4i,t} LNEMP_{i,t} +$$

$$\varphi_{5i,t} LNTA_{i,t} + \varphi_{6i,t} SOE_{i,t} + \varphi_{7i,t} IDIR_{i,t} + \varphi_{8i,t} Dual_{i,t} + \varphi_{9i,t} Fage_{i,t} +$$

$$\varphi_{10i,t} CEO\ age_{i,t} + \varphi_{11i,t} CEO\ edu_{i,t} + \mu Industry\ + \rho\ Year + \varepsilon_{i,t} \tag{11}$$

$$CERI_{i,t} = \varphi_0 + \varphi_{1i,t}\left(\sum LHCEO_{i,t} + MHCEO_{i,t} + HHCEO_{i,t}\right) + \varphi_{2i,t}EPS_{i,t} + \varphi_{3i,t}LEV_{i,t} + \varphi_{4i,t}LNEMP_{i,t} + \varphi_{5i,t}LNTA_{i,t} + \varphi_{6i,t}SOE_{i,t} + \varphi_{7i,t}IDIR_{i,t} + \varphi_{8i,t}Dual_{i,t} + \varphi_{9i,t}Fage_{i,t} + \varphi_{10i,t}CEO\ age_{i,t} + \varphi_{11i,t}CEO\ edu_{i,t} + \mu Industry + \rho\, Year + \varepsilon_{i,t} \quad (12)$$

$$CERI_{i,t} = \varphi_0 + \varphi_{1i,t}(HCEO_{i,t} * INVSIP_{i,t}) + \varphi_{2i,t}EPS_{i,t} + \varphi_{3i,t}LEV_{i,t} + \varphi_{4i,t}LNEMP_{i,t} + \varphi_{5i,t}LNTA_{i,t} + \varphi_{6i,t}SOE_{i,t} + \varphi_{7i,t}IDIR_{i,t} + \varphi_{8i,t}Dual_{i,t} + \varphi_{9i,t}Fage_{i,t} + \varphi_{10i,t}CEO\ age_{i,t} + \varphi_{11i,t}CEO\ edu_{i,t} + \mu Industry + \rho\, Year + \varepsilon_{i,t} \quad (13)$$

$$CERI_{i,t} = \varphi_0 + \varphi_{1i,t}(HCEO_{i,t} * INVSOP_{i,t}) + \varphi_{2i,t}EPS_{i,t} + \varphi_{3i,t}LEV_{i,t} + \varphi_{4i,t}LNEMP_{i,t} + \varphi_{5i,t}LNTA_{i,t} + \varphi_{6i,t}SOE_{i,t} + \varphi_{7i,t}IDIR_{i,t} + \varphi_{8i,t}Dual_{i,t} + \varphi_{9i,t}Fage_{i,t} + \varphi_{10i,t}CEO\ age_{i,t} + \varphi_{11i,t}CEO\ edu_{i,t} + \mu Industry + \rho\, Year + \varepsilon_{i,t} \quad (14)$$

$$CERI_{i,t} = \varphi_0 + \varphi_{1i,t}\left(\sum LHCEO_{i,t} + MHCEO_{i,t} + HHCEO_{i,t}\right) * \left(INVSIP_{i,t}\right) + \varphi_{2i,t}EPS_{i,t} + \varphi_{3i,t}LEV_{i,t} + \varphi_{4i,t}LNEMP_{i,t} + \varphi_{5i,t}LNTA_{i,t} + \varphi_{6i,t}SOE_{i,t} + \varphi_{7i,t}IDIR_{i,t} + \varphi_{8i,t}Dual_{i,t} + \varphi_{9i,t}Fage_{i,t} + \varphi_{10i,t}CEO\ age_{i,t} + \varphi_{11i,t}CEO\ edu_{i,t} + \mu Industry + \rho\, Year + \varepsilon_{i,t} \quad (15)$$

$$CERI_{i,t} = \varphi_0 + \varphi_{1i,t}\left(\sum LHCEO_{i,t} + MHCEO_{i,t} + HHCEO_{i,t}\right) * \left(INVSOP_{i,t}\right) + \varphi_{2i,t}EPS_{i,t} + \varphi_{3i,t}LEV_{i,t} + \varphi_{4i,t}LNEMP_{i,t} + \varphi_{5i,t}LNTA_{i,t} + \varphi_{6i,t}SOE_{i,t} + \varphi_{7i,t}IDIR_{i,t} + \varphi_{8i,t}Dual_{i,t} + \varphi_{9i,t}Fage_{i,t} + \varphi_{10i,t}CEO\ age_{i,t} + \varphi_{11i,t}CEO\ edu_{i,t} + \mu Industry + \rho\, Year + \varepsilon_{i,t} \quad (16)$$

Equations (11) - (16) describe the impact of hierarchical CEO succession and its three types (low medium and high on corporate environmental responsibility. Equation (13), the interaction term ($HCEO_{i,t} * INVSIP_{i,t}$) has revealed innovative strategy input as a moderator

while signifying whether a hierarchical CEO orientates towards innovative strategy or not? Additionally, equation (14) signifies the impact of innovative strategy output which is represented by the interaction term " $(HCEO_{i,t} * INVSOP_{i,t})$". Meanwhile, equation (15) and (16) accentuate the impact of innovative strategy input and output as a moderator under the aegis of three types of hierarchical CEO "$(\sum LHCEO_{i,t} + MHCEO_{i,t} + HHCEO_{i,t})$".

Empirical Results for Hierarchical CEO, Innovative Strategies and CER

The following tables illustrate the empirical results for hierarchical CEO and its three types which influence the corporate environmental responsibility via innovative strategies.
Table 1.18 has indicated that hierarchical CEO intensifies the corporate environmental responsibility (1st row of table 6). Through the comparison of coefficient values between cognitive CEO and hierarchical CEO (0.206* and 0.136* respectively), it has been substantiated that the impact of cognitive CEO is vigorous. Arguably, due to vulnerability, hierarchical CEO concentrates on performance rather than to orientate him/herself towards corporate environmental responsibility. Meanwhile, the variables "SOE", "IDIR" (Independent directors) and "Fage" (Firm age) have unveiled the positive significance which has already been indicated by previous tables (Table 1.15, Table 1.16, Table 1.17).

Table 1.18. GMM Instrumental Regression for Hierarchical CEO

	(1)	(2)	(3)
VARIABLES	CERI	CERI	CERI
HCEO	0.136*	0.148*	0.145*
	(0.058)	(0.053)	(0.059)
EPS	-0.200	-0.199	-0.190
	(0.191)	(0.191)	(0.195)
LEV	0.212	0.214	1.526**
	(0.488)	(0.488)	(0.492)
Degree	0.571	0.483	-0.362
	(1.200)	(1.230)	(1.257)
AGE		-0.327	-0.563
		(1.209)	(1.238)
LNTA	0.317*	0.318*	0.411**
	(0.175)	(0.175)	(0.177)
LNEMP	-0.254	-0.255	-0.523***
	(0.162)	(0.162)	(0.165)
Dual	-0.206	-0.205	-0.922**
	(0.377)	(0.377)	(0.383)
SOE	0.196**	0.195**	0.196**
	(0.064)	(0.063)	(0.054)
IDIR	0.175*	0.175*	0.275***
	(0.0996)	(0.0996)	(0.102)
Fage	0.438***	0.438***	

	(0.0279)	(0.0279)	
Industry $_{Dummy}$	Inserted	Inserted	Inserted
Year $_{Dummy}$	Inserted	Inserted	Inserted
Constant	49.75**	49.74**	46.27**
	(3.206)	(3.206)	(3.274)
Observations	5,199	5,199	5,199
R-squared	0.064	0.064	0.069

Standard errors in parentheses
**** p<0.01, ** p<0.05, * p<0.1*

Table 1.18 reveals that hierarchical CEO is positively significant for CERI (corporate environmental responsibility index). Moreover, "SOE", "IDIR" and "Fage" have also witnessed the positive significance for CERI (almost same results as represented by previous tables).

Table 1.19 reveals the positive relation of innovative strategy input (as a moderator) for corporate environmental responsibility. The coefficient value of the interaction term "HCEO*INVSIP" (0.0113*) is less than the coefficient value of the interaction term "LNCGCEO*INVSIP" (0.117*). Logical reasoning can be explained through the decision ability of these CEOs. As cognitive CEO has experience, knowledge and foreign exposure which assist him or her to take drastic steps for adopting CER measure while hierarchical CEOs are struggling due to their vulnerable position and cannot dare to invest in the R&D department and also they are least oriented towards CER. Further, column 3rd and 4th in Table 1.19 indicate the positive significance of innovative strategy output for CERI. Conclusively, the coefficient values (0.0564*, 0.0458*) of interaction term "HCEO*INVSOP" is less than the coefficient values of "LNCGCEO*INVSOP" (0.0737*, 0.0731*) which indicates whenever firms appoint hierarchical CEO, despite of attainment of number of patents, he or she has less orientation towards adopting the corporate environmental responsibility as compared to cognitive CEO. Additionally, the variables "SOE", "IDIR" and "Fage" have boosted CER activity intensively.

Table 1.19. GMM Instrumental Regression for Innovative Strategy Input & Output as A Moderator

	(1)	(2)	(3)	(4)
VARIABLES	CERI	CERI	CERI	CERI
HCEO*INVSIP	0.0113*	0.0105*		
	(0.0089)	(0.0070)		
HCEO*INVSOP			0.0564*	0.0458*
			(0.00957)	(0.00960)
EPS	-0.183	-0.153	-0.185	-0.191
	(0.191)	(0.195)	(0.195)	(0.194)
LEV	0.297	1.733***	0.283	0.215
	(0.487)	(0.489)	(0.492)	(0.493)
Degree	0.268	-0.446	-0.0351	0.175
	(1.232)	(1.261)	(1.417)	(1.426)
AGE	-0.769	-0.902	-0.728	-0.520

	(1.216)	(1.245)	(1.307)	(1.311)
LNTA	0.186	0.399***	0.161	0.315*
	(0.146)	(0.148)	(0.146)	(0.171)
LNEMP	-0.505***			-0.274*
	(0.165)			(0.129)
Dual	-0.156	-0.872**	-0.220	-0.220
	(0.379)	(0.385)	(0.382)	(0.380)
SOE	0.280**	0.372**	0.368*	0.367*
	(0.157)	(0.188)	(0.168)	(0.174)
IDIR	0.198**	0.230**	0.179*	0.199*
	(0.0795)	(0.102)	(0.107)	(0.108)
Fage	0.436***		0.433***	0.430***
	(0.0278)		(0.0281)	(0.0282)
Industry $_{Dummy}$	Inserted	Inserted	Inserted	Inserted
Year $_{Dummy}$	Inserted	Inserted	Inserted	Inserted
Constant	51.27**	49.17**	51.68**	50.25**
	(3.087)	(3.158)	(3.081)	(3.189)
Observations	5,119	5,119	5,203	5,199
R-squared	0.062	0.066	0.051	0.058

Standard errors in parentheses
**** p<0.01, ** p<0.05, * p<0.1*

Table 1.19 illustrates the positive significance of innovative strategy input as a moderator. Additionally, IDIR (independent directors), SOE (state-owned enterprise) and Fage (firms age) are also positively significant for CERI.

Table 1.20 elucidates that medium hierarchical CEO (MHCEO) intensifies the corporate environmental responsibility (1st and 2nd columns) while low and high hierarchical CEO (LHCEO and HHCEO) are insignificant. Convincingly, medium level board members in a hierarchical leader confront the vulnerability which compels them to be enthusiastic about performing work. Hence, medium hierarchical CEO successor concentrates on corporate environmental responsibility so that reputation of the firms may be elevated. Additionally, firms age (Fage), SOE (state-owned enterprise) and IDIR (independent directors) have a positive relationship with corporate environmental responsibility.

Table 1.20. GMM instrumental Regression for All Three Types of Hierarchical CEO

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	CERI	CERI	CERI	CERI	CERI	CERI
LHCEO			0.0242	0.0272		
			(0.0332)	(0.0330)		
MHCEO	0.0858**	0.0831**				
	(0.0391)	(0.0381)				
HHCEO					0.00633	0.00969
					(0.0128)	(0.0141)
EPS	-0.00217	-0.00159	-0.00207	-0.0272	-0.00203	-0.00200

	(0.00197)	(0.00195)	(0.00190)	(0.0330)	(0.00190)	(0.00190)
LEV	0.0182***	0.0175***	0.00224	-0.00205	0.00226	0.00292
	(0.00491)	(0.00489)	(0.00487)	(0.00190)	(0.00487)	(0.00485)
Degree	-0.00683	-0.00682	0.0144	0.00287	0.00477	0.00385
	(0.0112)	(0.0109)	(0.0137)	(0.00485)	(0.00959)	(0.00962)
AGE	-0.00820	-0.00853	0.00609	0.0145		-0.00432
	(0.0107)	(0.0105)	(0.0125)	(0.0137)		(0.00950)
LNTA	0.00366***	0.00384***	0.00307*	0.00592	0.00310*	0.00169
	(0.00148)	(0.00147)	(0.00169)	(0.0125)	(0.00169)	(0.00144)
LNEMP	-0.00513***		-0.00244	0.00171	-0.00251	
	(0.00164)		(0.00161)	(0.00144)	(0.00161)	
Dual	0.00467		-0.00232		-0.00216	-0.00214
	(0.0413)		(0.00378)		(0.00377)	(0.00377)
SOE	0.0198***	0.0195***	0.00231	-0.00233	0.00232	0.00194
	(0.00360)	(0.00355)	(0.00363)	(0.00378)	(0.00363)	(0.00363)
IDIR	0.00258**	0.00238**	0.00181*	0.00196	0.00182*	0.00160
	(0.00102)	(0.00101)	(0.000996)	(0.00363)	(0.000997)	(0.000989)
Fage	0.0904**	0.0937**	0.00432***	0.00159	0.00432***	0.00435***
	(0.00389)	(0.00384)	(0.000276)	(0.000988)	(0.000276)	(0.000275)
Industry $_{Dummy}$	Inserted	Inserted	Inserted	Inserted	Inserted	Inserted
Year $_{Dummy}$	Inserted	Inserted	Inserted	Inserted	Inserted	Inserted
Constant	0.498**	0.495**	0.504**	0.00435**	0.503**	0.517**
	(0.0315)	(0.0313)	(0.0315)	(0.000275)	(0.0315)	(0.0305)
Observations	5,077	5,203	5,199	5,203	5,198	5,202
R-squared	0.062	0.062	0.063	0.063	0.063	0.062

Columns 1st and 2nd in Table 1.20 illustrate that MHCEO (medium hierarchical CEO) is positively significant while LHCEO (low hierarchical CEO) and HHCEO (high hierarchical CEO) are insignificant. Meanwhile, SOE, IDIR and Fage have shown positive significance for corporate environmental responsibility.

Table 1.21 elucidates the innovative strategy input invigorates the CER activity under the patronage of medium hierarchical CEO (MHCEO). The coefficient value of the interaction term "MHCEO*INVSIP" (0.115* and 0.118* respectively). The interaction terms "LHCEO*INVSIP" and "HHCEO*INVSIP" are insignificant. Argumentatively, medium hierarchical CEO endorse corporate environmental responsibility, and they are also orientated towards executing innovative strategy. Meanwhile, SOE, INDIR and Firm age have been witnessed as an intensifier of CER activity.

Table 1.21. GMM instrumental Regression for All Three Types of Hierarchical and Innovative Strategy Input as A Moderator

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	CERI	CERI	CERI	CERI	CERI	CERI
HCEO*INVSIP	-0.00165	0.000901				
	(0.00637)	(0.00527)				
MHCEO*INVSIP			0.115*	0.118*		
			(0.089)	(0.089)		
HHCEO*INVSIP					0.0804	0.0569
					(0.0779)	(0.0825)
EPS	-0.210	-0.199	-0.159	1.832***	0.347	0.293
	(0.191)	(0.191)	(0.196)	(0.484)	(0.481)	(0.483)
LEV	0.244	0.294	1.770***			0.615
	(0.488)	(0.485)	(0.489)			(0.968)
Degree	0.883		0.306	-0.572	-0.570	-0.472
	(1.163)		(1.070)	(1.058)	(0.962)	(0.971)
AGE	0.119	-0.0983	-0.563	0.438***	0.150	0.290*
	(1.079)	(1.083)	(1.058)	(0.140)	(0.141)	(0.167)
LNTA	0.307*	0.167	0.469***	-1.011***		-0.251
	(0.170)	(0.144)	(0.145)	(0.381)		(0.162)
LNEMP	-0.243			1.905***	-0.157	-0.153
	(0.164)			(0.357)	(0.379)	(0.379)
Dual	-0.211	-0.217	-1.011***	0.318*	0.147	0.169
	(0.377)	(0.377)	(0.381)	(0.189)	(0.366)	(0.367)
SOE	0.226	0.195	1.905***	1.832***	0.155	0.176*
	(0.364)	(0.364)	(0.357)	(0.484)	(0.0995)	(0.100)
IDIR	0.173*	0.161			0.0804	0.0569
	(0.103)	(0.101)			(0.0779)	(0.0825)
Fage	0.433***	0.435***	0.436***		0.436***	0.433***
	(0.0278)	(0.0276)	(0.0279)		(0.0278)	(0.0279)
Industry $_{\text{Dummy}}$	Inserted	Inserted	Inserted	Inserted	Inserted	Inserted
Year $_{\text{Dummy}}$	Inserted	Inserted	Inserted	Inserted	Inserted	Inserted
Constant	50.43***	51.72***	49.63***	50.23***	51.95***	50.65***
	(3.158)	(3.048)	(3.154)	(3.069)	(3.005)	(3.110)
Observations	5,199	5,203	5,119	5,119	5,118	5,114
R-squared	0.063	0.061	0.061	0.058	0.062	0.062

Standard errors in parentheses

**** p<0.01, ** p<0.05, * p<0.1*

Table 1.21 indicates innovative strategy input as a moderator (MHCEO*INVSIP) is positively significant (1st and 2nd columns Table 1.21). However, the variables "LHCEO*INVSIP" and "HHCEO*INVSIP" are insignificant. On the contrary, SOE, Fage and IDIR are also positively significant for CERI.

Table 1.22 identifies that innovative strategy output boosts the CER activity under the aegis of medium hierarchical CEO (MHCEO) while the interaction terms (LHCEO*INVSOP)

and (HHCEO*INVSOP) remain insignificant. Intuitively, medium hierarchical CEO endorses CER activity and also concentrates on elevating the branding of the firms. Similarly, SOEs have been observed to be absolute promoter of CER activity. Additionally, matured firms and firms having a high number of independent directors always prefer to adopt CER activity.

Table 1.22. GMM instrumental Regression for All Three Types of Hierarchical CEO and Innovative Strategy Output as A Moderator

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	CERI	CERI	CERI	CERI	CERI	CERI
LHCEO*INVSOP	-0.0487	-0.0704				
	(0.0560)	(0.0579)				
MHCEO*INVSOP			0.0256*	0.0258*		
			(0.0151)	(0.0151)		
HHCEO*INVSOP					0.0170	0.0160
					(0.0356)	(0.0352)
EPS	-0.199	-0.166	-0.124		-0.165	-0.177
	(0.191)	(0.196)	(0.210)		(0.213)	(0.212)
LEV	0.220	1.724***	0.663	0.267	0.221	0.243
	(0.488)	(0.491)	(0.721)	(0.522)	(0.503)	(0.501)
Degree	2.041	2.490	0.404***	1.167	0.980	0.988
	(1.795)	(1.846)	(0.155)	(1.098)	(1.111)	(1.081)
AGE	0.217	0.771	0.532	-2.786	-1.700	-1.619
	(0.914)	(0.937)	(0.902)	(2.986)	(3.564)	(3.508)
LNTA	0.314*	0.393***		0.267	0.300*	0.341**
	(0.170)	(0.147)		(0.178)	(0.176)	(0.173)
LNEMP	-0.248		(0.171)	0.350*	-0.312	-0.259
	(0.161)		-0.245	(0.203)	(0.208)	(0.196)
Dual	-0.261	-1.008***	(0.167)	-0.448	-0.357	-0.487
	(0.382)	(0.390)	-0.432	(0.477)	(0.492)	(0.526)
SOE	0.216	1.943***	1.712***	1.716***	0.744**	
	(0.364)	(0.356)	(0.409)	(0.410)	(0.435)	
IDIR	0.173*	0.231**		0.272*	0.235*	
	(0.100)	(0.102)		(0.143)	(0.144)	
Fage	0.434***		0.426***	0.410***	0.419***	0.426***
	(0.0278)		(0.0305)	(0.0377)	(0.0400)	(0.0424)
Industry $_{\text{Dummy}}$	Inserted	Inserted	Inserted	Inserted	Inserted	Inserted
Year $_{\text{Dummy}}$	Inserted	Inserted	Inserted	Inserted	Inserted	Inserted
Constant	50.33**	49.52**	51.24***	51.52**	50.76**	51.46**
	(3.162)	(3.135)	(3.198)	(3.341)	(3.343)	(3.453)
Observations	5,199	5,203	5,199	5,199	5,199	5,199
R-squared	0.058	0.054	0.054	0.054	0.055	0.051

Standard errors in parentheses
**** p<0.01, ** p<0.05, * p<0.1*

Table 1.22 has revealed that the interaction term (MHCEO*INVSOP) is positively significant for CERI while the interaction terms (LHCEO*INVSOP) & (HHCEO*INVSOP) are

insignificant. Additionally, SOE, Fage and IDIR are all positively significant for CERI (same results as represented by the previous tables).

Chinese firms have adopted innovative measures while adhering to the corporate socially responsible and corporate environmental responsibility measures so that organizational structure may be standardized. However, the Chinese CEO is under influential control of the government due to having major stakeholders. Despite this intervention, the role of the CEO is essential while making an abrupt decision during dynamic circumstances. Unfortunately, CEOs among Chinese firms are forcefully turned over regarding poor performance (He and Huang, 2011; Hu and Leung, 2012), and the appointment of a novel successor is allocated while selecting a board member within the hierarchical ladder. In this regards, hierarchical CEO has been formulated through analyzing the hierarchical positioning of board members among the listed firms. To contemplate deeply, hierarchical CEO has been categorized into low, medium and high hierarchical CEO (Shah et al., 2019; Sarfraz et al., 2019) signifying medium hierarchical CEO as a promoter of corporate environmental responsibility. Meanwhile, cognitive CEO exhibiting specific types of characteristics (Li et al., 2020) has been formulated who enforces his upper-echelon team towards disclosing the CER activity.

Further, both cognitive CEO and hierarchical CEO have been examined to be the least concern about allocating funds in the R&D department. Arguably, the cognitive CEO and hierarchical CEO prefer those innovative strategies which are ultimately conducive for the future growth of the firms. Hence, both cognitive CEO and hierarchical CEO concentrate on invigorating the innovative strategy output. Decisively, the empirical underpinnings reveal that the impact of cognitive CEO on CER is vigorous as compared to hierarchical CEO. Additionally, the empirical results entail that the role of independent directors is inevitable while assisting both cognitive CEO and hierarchical CEO through their vigilant surveillance towards adopting CER activity. Meanwhile, matured firms and SOEs have been witnessed to be an advocator of CER activity under the aegis of innovative strategy input or output.

Convincingly, based on our results, the study divulges some practical implications for organizational theorists, practitioners, and scholars. This study recommends that the position of CEO should be selected based on specific attributes such as CEO age, CEO education, goodwill, and attainment of tacit knowledge rather than to select abruptly from board hierarchy. Arguably, whenever a cognitive CEO has been appointed, he or she must be independent while deciding how to allocate funds between the R&D department and corporate environmental responsibility. Suggestively, the role of independent directors is also necessary who can orientate both hierarchical CEO and cognitive CEO towards adopting the CER measures.

Doubtlessly, the study has contributed through formulation of cognitive CEO and hierarchical CEO while contemplating the effectiveness of innovative strategies as a moderator. However, this study has certain limitations. Firstly, the study has demonstrated the impact of cognitive CEO, but future study can contemplate the cognitive independent directors while influencing the firms' growth. Secondly, this study has neglected gender differences among both cognitive CEOs and hierarchical CEOs which future study can contemplate empirically. Lastly, the

impact of hierarchical CEO and cognitive on firms' risk will be a new direction for future research.

The organizational approach of sustainability and the development of frameworks determine the simulation of organizational models. Below are presented a series of organizational models, in different fields of activity. Proposed organizational models involve a certain advancement of technology. We cannot address sustainability without involving the latest technologies in the areas of activity addressed.

1.3. Models for sustainable development and information technologies

1.3.1. Business models for sustainable development in the circular economy context

The concept of sustainable development is interesting for most practitioners, decision-makers, stakeholders and researchers (Reynaud, 2010). By definition, sustainability implies a balanced assessment of the three dimensions and resource efficiency. Organizational involvement in sustainable development implies the implementation of tools, methods or models to improve organizational work. In many cases, these tools or models have been included in a series of sustainable development models. In the literature, there are a number of proposed models for sustainable development based on the triple bottom line or other tools. Few researches present an inventory of these methods.

Sustainability refers to the resources depletion or events that have a negative impact on the environment (damage), currently or at a given time projected in the future. Sustainability issues are manifested by depletion or lack of resources, diminishing resource quality, resource degradation, deliberate or accidental destruction of resources for short-term gains, or a deficiency between resource relationships. Globally, for most of the history, the size of the population was small enough that there were no significant resource losses, resource limitations that were regenerated or rebuilt naturally. In recent years (Thatcher, 2014), resource limitations and disruptions resulting from natural cycles (Bates et al., 2008; Vitsousek, 1994) have led to serious human tragedies such as negative impacts on human health and well-being (Pimentel et al., 2007), climate changes (Rada and Cioca, 2017), excessive occurrence of heat islands (Thatcher, 2014), excessive pollution in urban areas (Ivascu et al., 2015), social system disorders (Wilkinson & Pickett, 2009) and much more. As Hecht et al. (2012) the challenges are multidisciplinary, immense and complex: "There must be considerable improvement infrastructure for water systems, sewerage and urban development, reduce hunger, alleviate poverty and promote human dignity, reduce greenhouse gas emissions, avoid persistent chemicals, bio accumulative and toxic, and biodiversity protection ". In this context, business models should be formulated to contribute at least to maintaining resources over the years (Moraru and Babut, 2014). These models should be references to organizations in order to increase their competitiveness in the business environment.

Organizational tools contribute to improving organizational work for sustainable development. There are a number of instruments that refer to the environment without reference to other dimensions. Table 1.23 show a series of tools used in SD (Thatcher, 2014; Ivascu et al., 2015;

Rada and Cioca, 2017). Instruments are classified by action categories. These tools (Thatcher, 2014) must be:

a. flexible – easy to adopt, consistent with organizational policies and cultures
b. updated – to contribute sustainably to organizational competitiveness
c. compatible with other tools - to have the ability to be combined with other tools
d. affordable – to allow easy understanding of all stakeholders
e. in accordance with mission, vision and organizational objectives.

Table 1.23. Tools, methods and methodology for the sustainable development of organizations

Category	Tool	Description	Assessing benefits for sustainability
Production	Life cycle assessment/ Life Cycle Sustainability Assessment	A systematic set of procedures for assessing and examining inputs and outputs of materials and energy and the associated environmental impact which are directly attributed to the functioning of product or service processes throughout its life cycle.	This assessment and review is based on three dimensions: economic, social and environmental. Increasing the product / service durability.
	Lean manufacturing	It focuses on minimizing waste in production systems and simultaneously maximizing productivity.	Minimizing waste and streamlining production processes are targeted by SD.
	Kanban, Kaizen, Kaikaku, Six Sigma, 5S, Scrum	Lean manufacturing tools aim at radical change, minimizing waste and maximizing production.	It contributes to improving the efficiency of production processes.
	Value Stream Mapping	Performance management tool. It helps the organization visualize the steps needed to create the product until it is delivered to the final customer. The business mapping method.	Introspection activities and process improvement are SD approaches.
	Material analysis	Identifies critical economic, environmental and social aspects that can highlight a significant impact on business performance, and can substantially influence stakeholders' assessments and decisions.	It directly targets the sustainable development of the organization, taking into account the three dimensions: economic, social and environmental.

	7 Waste	It involves evaluating and minimizing the 7 types of waste: defects, overproduction, transport, waiting, inventor, movement and processing.	It refers to the sustainability of organizational processes.
Financial	Benefit-cost analysis	Estimates and summarizes the equivalent value of benefits and costs to stakeholders.	It refers to the economic dimension of SD.
	Financial indicators	Evaluates the organization's economic performance and contributes to more efficient work. It is a support for stakeholders' decision-making.	It refers to the economic, social and environmental dimensions of SD.
Management	Business canvas	Helps to understand own business model or competitor. Provides information about: customers, channels that bring value and financial performance.	It helps make the best decisions for SD.
	Business environmental assessment	Evaluates the impact of business on the environment using specific tools (internal and external environment analysis).	It presents a situation of internal and external environment. Used in SD of the organization.
	Scenario analysis	Process to estimate the expected value of a portfolio after a certain amount of time. It is assumed that specific changes were made to portfolio securities or key factors.	It helps to improve the economic dimension of SD and stakeholder decisions.
	Stakeholders' analysis	They are stakeholders of a company. They can affect or be affected by a business. Contributes to decision-making.	It helps the SD of the organization by making the best decisions.
	Problem-solving	Identifies and solves organizational problems. It may include mathematical or systemic approaches.	An important part of SD in the decision-making process.
Risk manage	Identifying hazards	Stage identifying hazards that may lead to risks. It is the basic stage for risk assessment.	Identifying hazards is important for the organization's SD.

	Risk assessment	Evaluates risks after identifying the hazards. It is the basis for the control stage.	Risk and Impact Assessment is important for SD.
	Occupational health and safety (OSH)	Occupational risk assessment addresses the health and safety of human resources in an organization. OSH is important for any organization.	It contributes to the development of sustainable jobs and to minimizing accidents.
Environmental impact	Environmental Management System (EMS)	Set of processes and practices that help reduce environmental impact and increase operating efficiency. It focuses on reducing the organization's environmental footprint.	It refers to the environmental dimension of SD and the reduction of environmental pollution.
	Resource Efficient and Cleaner Production (RECP)	Involves continuous application of environmental strategies for processes, products and services to increase efficiency and reduce risks to humans and the environment.	It addresses the three dimensions: increasing economic performance, minimizing environmental impact and social improvement of employees and society.
	Circular, green and bio-economy	Evaluates sustainability of economic responsibility by streamlining economic results.	It targets the SD's economic responsibility.
	Waste management	Organizational waste management to make work more efficient.	It targets the organization's SD, especially its environmental dimension.
	Ecosystem Services Valuation	These ecosystem services are products and services that contribute to human well-being and are generated by processes.	Supporting products and services that meet the society's requirements contribute to sustainable development.
	Eco-Management and Audit Scheme (EMAS)	A tool developed by the European Commission for organizations to assess, report and improve their environmental performance.	It refers to the environmental dimension of SD organizations.
Other tools	ISO Standards	International standards that address a series of procedures that help increase competitive advantage.	Different standards refer to all dimensions of sustainability.
	Innovative indicators	Innovative indicators can target different aspects of organizational development.	It refers to different activities that contribute to organizational sustainability.

Sustainable development models

There are a number of sustainable development models in the literature, starting from the basic model, the "triple bottom line", to integrated tools. Below are some tools for evaluating SD.

- ✓ **Triple bottom line (Three pillars model)**

Triple bottom line (Three pillars model) is the basic model for sustainable development (World Summit of the United Nations, 2005). The representation of the model in the form of pillars, overlapping or triangular circles refers to the three dimensions: economic, social and environmental. The name "pillar" changes between different versions of the model, according to the researcher. Thus the names of: pillars, dimensions and responsibilities are met. The economic dimension addresses the economic aspects of the organization. The social dimension targets employees of the organization and society. The environmental dimension addresses pollution-induced aspects. There are two basic approaches to this model. The first is the assumption that "pillars" are independent constructions (Rada and Cioca, 2017). The second approach claims that the three dimensions are interconnected and intersect. It is claimed that most of the resources come from nature as ecosystem services and it is impossible to separate human development from the development of the environment. At the same time, economic implications are found in everyday life, so that there can be no separation of the economic dimension from the social and the environmental one. This approach includes several definitions of definition, as follows:

- ✓ economic capital, social capital, and natural capital (Dyllick and Hockerts, 2002)
- ✓ business, society, and nature (Dyllick and Hockerts, 2002)
- ✓ economic, social, and environmental (United Nations World Summit, 2005)
- ✓ economic growth, social progress and environmental protection (Kates et al., 2005)

It can be noticed that after the UNWS definition, the development of sustainability is based on the three dimensions: economic, social and environmental. Prior to this date, the definition was based on capital and business.

- ✓ **Prism model (four pillars model)**

It is similar to „the three pillars", but proposes another dimension. Spangenberg & Bonniot (1998) refer to human capital, social capital, cultural capital and natural capital. Other four-dimensional models include the three-pillar basis, but separating cultural capital from social capital. Thus there are four dimensions.

- ✓ **Nested circles of sustainability**

Based on the three-pillar model and the prismatic model of sustainability, the "egg of wellbeing model" represents the relationships between the different dimensions as concentric oval. This model is extracted from the definition of sustainable development of IUCN (1991) and uses the definition as an egg (Guijt et al., 2001). White egg (white) is the ecosystem surrounding the yellow portion of the egg (yolk) that represents humans. The state of health of the egg is considered complete only when the health of each individual subsystem is fulfilled. This representation of egg sustainability is based on the three-dimensional or four-dimensional model, except that the human subsystem is considered as a single subsystem that integrates several components (health and well-being of the population, wealth, knowledge, professional development, culture, community, integrity and equity). Together they form an ecosystem.

- ✓ **The basic concentric circles model**

This model is similar to the "egg of wellbeing model", except that there are several concentric subsystems. The smallest, the most central, is economical. It is covered by the second

concentric circle representing the human society subsystem. The largest circle that encapsulates the economic and social subsystem is the natural environment (Mitchell, 2000). This concentric representation emphasizes that each circle is constrained by others (the development of the natural environment is limited by the link with society and economic development).

- ✓ **Two-tiered sustainability equilibria model of sustainable development**

In the literature, some researchers claim that the concentric representation of sustainability is rigid and does not fully meet the definition of usability. Lozano, 2008, states that for a real sustainable development, the three circles should overlap completely and thus the concept of "first tier sustainability equilibrium" (FTSE) appears. This stage describes the interdependencies at the present moment. The second stage includes the time dimension by representing the FTSE as a perfect cylinder. If the importance of the present or of the future is more emphasized, then the cylinder would look more like a cone. The third stage implies that sustainability is a dynamic process, and time is an important component. This is the sustainability in the form of a donut. This idea argues that decisions on sustainable development form the availability of future sustainable development decisions in the future (closed loop).

- ✓ **Five-dimensional model of sustainability**

In Seghezzo's vision (2009), sustainability is defined by the intersection of three concentric circles, integrated into a triangle. This representation integrates the three dimensions of the conventional space geometry. The triangle's peaks are represented by: intra-generational justice, inter-generational justice, and identity / happiness. The inner circles are: persons, place, and permanence. These diagrams are disposed within the triangle.

- ✓ **Four-dimensional model of sustainability**

In another vision (Izvercian et al., 2014), sustainable development is based on the triple line, but adds a fourth dimension called "technology". This approach considers technology as an integral part of the economic, social and environmental dimensions, but it is also an entity. Technology is important in any field. Far be it, the efficiency of the activities would not be possible, as stated in this proposal.

Proposal of a theoretical model for sustainable development

Based on the tools presented in Table 1.23 and sustainable development definition models, this section presents a theoretical model for the sustainable development of organizations, Figure 1.20. The environmental dimension includes the three major development directions: maximize material and energy efficiency, using the closing resource loops, and 13 R's of sustainability. The social dimension includes the three important directions: employee involvement in the organization's activities, involvement of the organization in society, and involvement of stakeholders. The economic dimension includes: repurpose for society environment, development of circular economy, and operational efficiency.

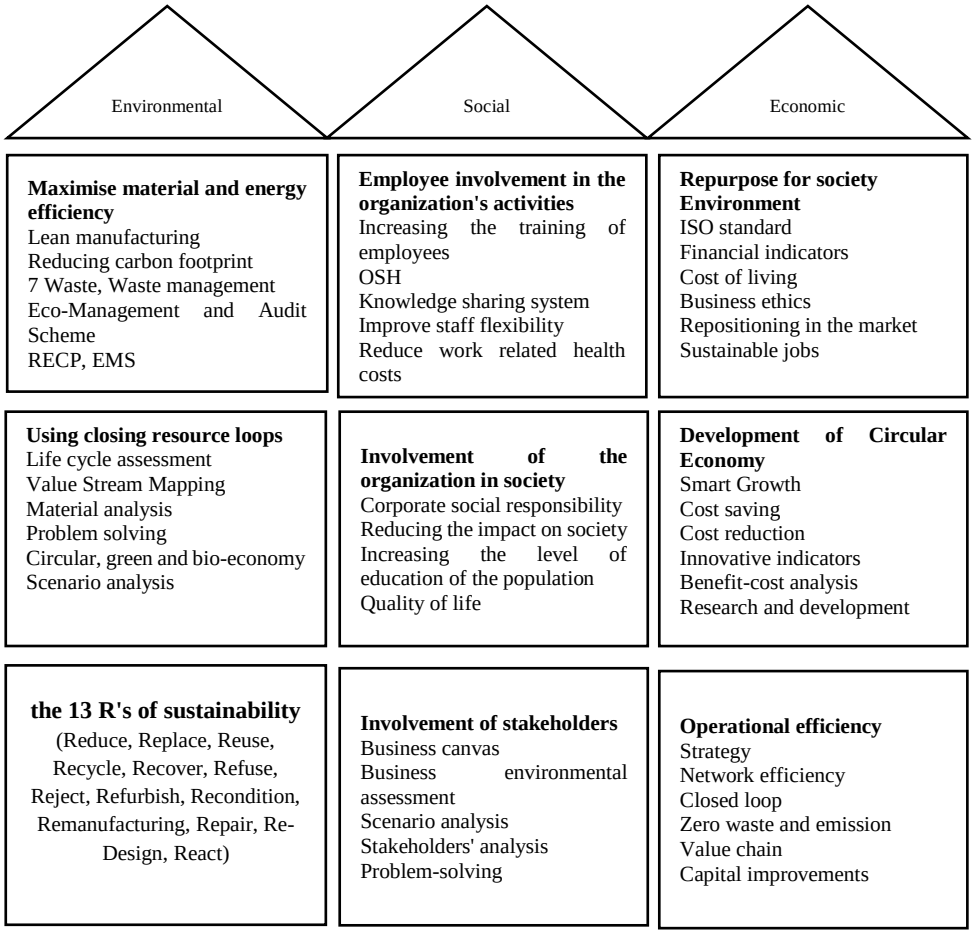


Figure 1.20. The theoretical model proposed for sustainable development

All models acknowledge that adopting a strategy for sustainable development involves coordinating a complex set of interrelated factors (although there is still considerable disagreement about the composition of the set of important factors and the degree of interdependence). The approaches presented above support the idea of integrating the three dimensions: economic, social and environmental. Various studies show that there is a relationship of interconnection of these dimensions and that there is no organizational development unless all three dimensions are considered. Integrating sustainability into organizational culture is based on a series of stakeholder decisions. These decisions must be ethical, integral and fair.

1.3.2. Measuring the implications of sustainable manufacturing in the context of Industry 4.0

Sustainability is increasingly being addressed globally. The manufacturing industry faces various constraints and opportunities related to sustainable development. Currently, there are few methodological frameworks for evaluating sustainable organizational development. Assessing and improving organizational capacity is important for producers and researchers in the field, local, national and international authorities. This section proposes a hierarchical framework for sustainability assessment of manufacturing industry in Romania. The proposed framework integrates performance elements and measures to improve all the processes and activities from the triple perspective of sustainability. Sustainability assessment captures the

entire supply chain of the organization, including stakeholder interests and end-of-life directions for products. To establish the elements to be integrated in the development of the proposed framework, market research (online questionnaire - for the characterization of Industry 4.0) and the Delphi method were used to identify the categories of performance indicators that must be measured to identify the organizational capacity for sustainable development. The framework was tested by an automotive manufacturing organization. A number of improvements have been identified that relate to Industry 4.0 facilities and the application of the facilities related to recovering the value of the product at the end of its life cycle. This hierarchical framework can be customized in detail for the specific of each organization and can be adapted in other industries: banking, retail and other services. It can be observed that waste management and the interests of the stakeholders are major implications that must be measured and properly motivated.

Sustainability and sustainable development as concepts have gone through different development stages since their introduction. The historical development of the concept has been carried out at various conferences, within organizations and institutions, which are currently concerned with the implementation of the principles, targets and objectives of sustainable development (Malthus, 1926). The concept of sustainable development has encounter over time different criticisms and interpretations, being accepted in different fields of activity. The concept of sustainable development, throughout its evolution, has adapted to the environmental and technological requirements, but the heart, the principles, directions and objectives have been preserved and are still present. Due to the fact that the environment is dynamic and different new aspects come in, some sustainable development goals have been updated. The objectives of sustainable development are contained in the 2030 Agenda. At the same time, the objectives of this agenda contribute to the survival on the planet and to the increase of the standard of living (Malthus, 1926; Mitcham, 1995).

If initially the sustainable development focused more on the environmental dimension, gradually there were added obligations regarding the social and economic dimension. The concept of sustainable development has become one appreciated by organizations due to the identification of organizational benefits and advantages (United Nations. 1972; Zimmerman, 1962; Cioca et al., 2015). The social and economic aspects are addressed and appreciated by the organizations involved in sustainable development (Chang et al., 2015). Five decades ago, the society was characterized by consumerism, economic growth, polluted living space and unorganized way of living (Garcia-Torres, 2017). The exploitation of some natural resources contributes to the entrenchment of the right to a decent living for the next generations. The needs of the population are inversely proportional to those of the organizations. Imbalances in the environment contribute to the generation of negative effects for future generations. Pollution is a major environmental problem. Among the sources of pollution are: (1) the development of the economic environment (economic growth, traffic intensification, traffic improvement, increasing the number of inhabitants, increased tourism and others), (2) natural hazards (earthquakes, severe rain, volcano eruptions, droughts , wind and others), (3) technology (different networks built, new concepts, intensification of the use of information technology, construction of different attractive products for users, waste management and

others) (Siew , 2015; Amui et al., 2017; Steen, 1999; Beatriz, 2018). These factors contribute to the occurrence of consequences, some severe, which concern ecological problems, ecosystem instability, global climate change, natural disasters, hunger and poverty, lower quality of life and others (Steen, 1999; Beatriz, 2018).

The global scenario of depletion of natural resources and environmental, economic and social imbalance motivates organizations and individuals to adopt sustainability practices in organizational processes. Sustainability was born many years ago, but few guidelines are available for its practical implementation and evaluation. The source (Steen, 1999; Beatriz, 2018) states a considerable impact of sustainability on the environment. This research presents the impact of greenhouse gases and waste on the environment. Reference is made to the wood industry, energy and heat generation. The source (Cioca et al., 2015) states that sustainability is achieved in the field of transport and adjacent industry and emphasizes the reduction of environmental impact. The research (Chang et al., 2015) presents sustainability studies in the airline field and it is said that automotive industry must be evaluated and analyzed in future research. The research (Garcia-Torres, 2017) presents the impact of sustainability in the fashion industry. The research (Siew, 2015) presents the impact of sustainable development in the foam and chemical industry, presenting different visions. It is specified that the automotive industry has a considerable impact in the field of sustainability, without specifying these impacts. The research (Amui, 2017) has various implications for the food industry. From the analysis of the different definitions discussed in studies (Siew , 2015; Amui et al., 2017; Steen, 1999; Beatriz, 2018) it was observed that the approach on sustainability in manufacturing is not yet concretely developed. Sustainable development improves the conditions of companies contributing to their competitiveness. Sustainable development is a voluntary approach, but increasingly approached by companies. Stakeholders are interested in this concept as long as they get improved financial results (increased profit). The first direction was the one of environmental sustainability, with major implications of national, international authorities and organizations (Garcia-Torres, 2015). However, sustainability is defined by three dimensions: environmental, social and economic (Steen, 1999). The research (Cioca et al., 2015; Chang et al., 2015) is addressed sustainability in land and air transport industry. It emphasizes the importance of addressing sustainability in this industry as a result of generating a large amount of greenhouse gases. The results published in the reference (Garcia-Torres, 2017) highlight the impact of sustainability in the fashion industry and the impact it has social impact by producing the articles used by the final customer who is in the society. The importance of occupational safety and health in this industry is also mentioned. This industry focuses on re-manufacturing, reconditioning of items and use for other purposes, reuse of other people's items, recycling materials by implementing the buy-back concept (in various stores), reducing the impact on the environment by using natural materials (bio-cotton, wool and others), repair and recovery of items to meet basic need, redesign of the manufacturing process by including automatic lines and reconditioning of items to be used until the end of the life cycle. The research (Siew, 2015) presents studies in the foam and chemical industry and emphasizes the importance of renewable energy sources. In the same direction as the fashion industry, the food industry is one that addresses the end customer, and the functions of sustainability are addressed. Research (AMui et al., 2017) in the food industry refers to the 9Rs (remanufacturing, reconditioning, reuse,

recycling, reduce, repair, recover, redesign, and reconditioning). The importance of the 9Rs in the entire manufacturing is underlined.

This part of research (Steen, 1999) specifies the imperatives of Industry 4.0 and its importance in the current economic development. Therefore, 5 important reasons can be systematized. Sustainable manufacturing is one of the most important issues to address for the following five important reasons (Cioca et al., 2015; Chang et al., 2015; Garcia-Torres, 2017; Siew, 2015; Amui et al., 2017; Steen, 1999):

a. The manufacturing generates a significant quantity of greenhouse gases alongside the energy and transport industries (Cioca et al., 2015; Chang et al., 2015).

b. It has social impact by producing the articles used by the final customer who is in the society, but also on occupational safety and health (Garcia-Torres, 2017).

c. The high impact it has due to the huge energy consumption and on the use of physical resources (Siew, 2015).

d. Adopting the functions of sustainability: remanufacturing, recondition, reuse, recycling, reduce, repair, recover, redesign, and recondition (9R) (Amui et al., 2017).

e. Adopting Industry 4.0 imperatives by integrating its requirements into sustainable development (Steen, 1999).

Organizations implement various strategies, in accordance with the interests of the stakeholders and good practices to make the processes environmentally efficient, sufficiently socially and economically viable. Therefore, it is suggested that manufacturing integrate production processes that pursue sustainable manufacturing practices. It is imperative that a study should include all aspects of sustainability related to stakeholder involvement, the entire logistics chain and strategies up to the end of product life.

The practices, methods and tools used for sustainability assessment in the manufacturing industry are based on a pioneering roadmap for applying the imperatives of the circular economy in the context of Industries 4.0. The results of this research refer to the presentation of the relationship between circular economy and Industry 4.0, as well as the improvement of the ReSOLVE method for the business environment (Beatriz et al., 2018). It is an approach based on specialized literature and qualitative evaluation. Another model (Luiz et al., 2019) aims to integrate technologies from Industry 4.0 integrated with circular economy (EC) practices to provide a business model. This business model is based on the reuse and recycling of ferrous materials and waste. It is based on qualitative evaluation. A study (Neligan, 2018) of 600 German companies claims that the opportunities of digital networks are used to a limited extent, especially for streamlining production processes. This study does not present an improvement framework, but only an evaluation of the results obtained from the market research. Other research (Okorie et al., 2018) offers a synergistic and integrative circular economy-digital technologies framework based on the empirical literature. The research results state that the research directions of the circular economy have been submitted, but the research and applicability of the digital technologies that allow an EC are still in the basic form. The

study (Arena et al., 2013) presents "X" production systems (XPS) and the importance of lean manufacturing and continuous improvement principles. It presents the situation of a company that has better aligned its XPS with the sustainability objectives. Following the research, the indicator panel and the evaluation framework are completed. The research (Ahmad et al., 2018) takes into account the life cycle of the product, stakeholders, employees and customers, end-of-life strategies, but also included environmental, social and economic aspects in a single comprehensive review on the aforementioned directions. The result highlighted an integrated approach based on various researches in this direction.

In summary terms, other researches are based on sustainable value stream mapping (Sangwan, and Mittal, 2015) use of multi criteria decision making (Baud, 2008), assessment questionnaire (Sangwan, and Mittal, 2015; Garetti, and Taisch, 2012) indicator based assessment (UN General Assembly, 2015; Adams, and Ghaly, 2016), rating system (Baud, 2008), scoring tool (Adams, and Ghaly, 2016), software tool (Garetti, and Taisch, 2012), mathematical modeling (Many et al., 2013) life cycle analysis (Marchese, 2018; Rajak, and Vinodh, 2015; Azapagic, 2004), product service system (Azapagic, 2004), sustainability index (Veleva, and Ellenbecker, 2001). By evaluating these approaches, it can be seen that the research covers the evaluation of the sustainability, the measurement of the performance taking into account certain practices and indicators. Therefore, an integrated framework for sustainability assessment, including product life cycle engineering, stakeholder interests, supplier and supply chain management, employees and customers, end-of-life strategies is impetuous to develop. These approaches (Sangwan, and Mittal, 2015; Garetti, and Taisch, 2012; Azapagic, 2004; Veleva, and Ellenbecker, 2001) are applied on specific business typologies, without taking into account the opportunities and requirements of Industry 4.0. The framework that is desired to be developed in this research takes into account the behavior of different companies in the manufacturing industry and the characteristics of the Industry. 4.0. These studies do not take into account the characteristics of Romanian manufacturing industry. At the same time, it does not hold a debate with experts in the field to substantiate the proposed framework.

This section presents a new evaluation framework, which integrates the goals of sustainable development and those of Industry 4.0. To develop this framework, a market research was conducted to identify the current needs and implications in Industry 4.0. This research was validated following discussions with manufacturers in the manufacturing industry. These debates were based on the Delphi method to arrive at a form of those discussed agreed by all key subjects. Finally, a hierarchical framework was developed based on the needs identified and validated through the Delphi method. This framework is used to evaluate, improve the involvement of companies in the manufacturing in sustainable development and reduce the negative impact on the environment.

Research methodology

The research methodology comprises three research directions: market research by means of a questionnaire applied to 100 manufacturing industry experts, Delphi method involving 1 facilitator and 40 experts and the author's empirical experience. All the phases of the research are progressively completed, and finally the proposed framework is pre-tested and validated.

a. The questionnaire

Marketing research helps to identify the needs and desires of the clients (Fernández et al., 2014). There are a number of tools, but questionnaire survey is a facile, cheap and easy to apply way. The questionnaire provides an easy to apply way to a number of individuals (Oliva-Maza, et al., 2019; Herrmann et al., 2014; Herrmann et al., 2007; Chou et al., 2015; Bala et al., 2015Salvado et al., 2015). Various questions may be asked depending on the type of information that is to be obtained. Can be used open-ended questions (completely unstructured, structured, describing an image), closed questions with predetermined answers (with different scales: Stapel, semantic differential, constant amount appreciation attribute) or mixed questions. If it is desired to collect some motivations and opinions regarding the creativity and innovation of the respondent, then the open questions will be used. If all the answer variants can be anticipated, then the closed questions will be used. In other situations, mixed questions can be used (Hermann, 2014).

In this research, the questionnaire was used to identify the characteristics and imperatives of Industry 4.0 for Romania. This research tool has been applied to shareholders throughout Romania. There have been 100 shareholders, directors or managers. The p-value> α at a 95% confidence level and then the null hypothesis is not rejected based. The 100 companies were selected from the classification of companies based on turnover (1), net profit (2) and number of employees (top 100 companies). This classification was made on the basis of data from the Trade Register and National Institute of Statistics. The application of the questionnaire was done online, punctual to each previously identified respondent. The respondents were identified according to the activity field of the company. It was intended to cover all areas of activity in the manufacturing industry. All responses were valid. Likert scale (1 least important and 5 most important), distribution of a set score (0 - poorly implemented and 100 - fully implemented) and open questions were used. The questionnaire was structured on 4 parts: information about the company, Industry 4.0 - Interpretation, facilitators and barriers, Industry 4.0 - Maturity and National Technology Platform Industry 4.0. The results obtained in this research are used to develop the hierarchical framework for sustainability assessment of manufacturing industry. The structure is presented in Table 1.24

Table 1.24**.** Sustainable development and Industry 4.0

Direction	**Investigated Elements**
Company information	Activity domain Identification of the best-selling product Number of employees Assessment of the level of innovation of the company (0-100)
Industry 4.0 - Interpretation, facilitators and barriers	Identification of company practices in Industry 4.0 Evaluation of Industry facilitators 4.0 Barriers of Industry 4.0
Industry 4.0 - Maturity	Identifying the degree of maturity Evaluation of a proposed model for digital maturity that includes: strategy, technology, operations, organization and culture and clients.

National Technology Platform Industry 4.0.	Evaluation of the national platform Industry 4.0 Assessment of the importance of the actors of the Industry 4.0 platform: government, universities and research institutes, users-companies of Industry 4.0 and suppliers of Industry 4.0 The level of resistance to digitalization Transforming the company into the digitalization era

b. Delphi method

The Delphi method is a forecast framework that includes the results of several rounds of questionnaires sent to a group of experts (Arena et al., 2013). The results of a round are recorded, and then they are sent to the expert group, and the anonymous responses are aggregated and shared again to the expert group (Ahmad et al., 2018; Sangwan et al., 2015). The process followed for applying this method is shown in the figure below. The Delphi technique is a method used to estimate the probability and outcome of future events. The expert group exchanges opinions and each personally provides estimates and assumptions based on experience to a facilitator who examines the data and develops a summary report. Experts review the form of the report and a new (second) report is issued. This process continues until all experts / participants agree with the developed report. This technique is an iterative one and is successfully applied in management and in different approaches to competitiveness (Baud, 2008). In this area sustainable development also has its place (Salvado et al., 20115). The Delphi method clarifies and extends problems to identify all areas and features that need modification (Buyya et al., 2018). In the present research we used the Delphi method to identify all sustainable performance measures for improving organizational policies, people, processes and products. The following steps are presented in Figure 1.21. For the application of this method, a facilitator was identified, from the automotive industry, being the manager of the processes and research-development department. The facilitator is characterized by: over 30 years' experience in manufacturing, the manager of a company with over 3000 employees, personal involvement in sustainable development, good communicator and has the capacity to analyze (as a result of the competences registered on the basis of certificates obtained at international level).

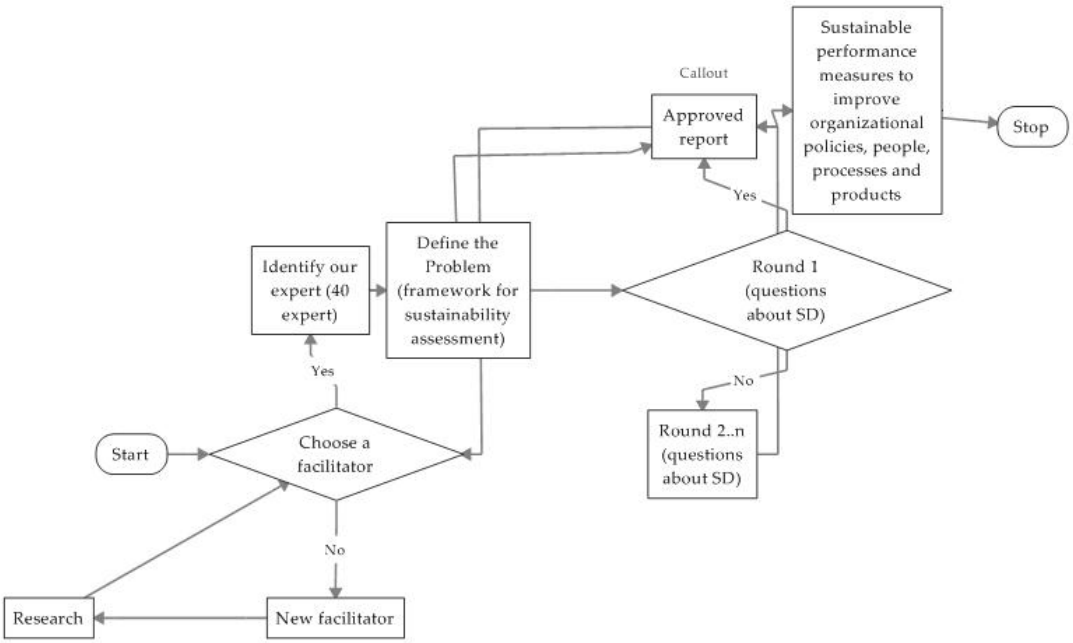


Figure 1.21. The stages of the Delphi method used in establishing the hierarchical framework for sustainability assessment of manufacturing industry

The automotive industry has a significant percentage of manufacturing in Romania (it generates over 15% of gross domestic product (Hsiao, 2013; Hallstedt, 2017; Wilkinson, and Cope, 2015; Gasparatos, and Scolobig, 2012). Industries have their peculiarities and must be evaluated in a complex way (Mayyas, et al., 2012; Petruse, et al., 2016; McAuley, 2003; National Intitute of Statistics, 2020). The construction of the sample of respondents from different fields contributes to the achievement of an integrated framework for evaluating sustainable development (Muñoz-Villamizar, et al., 2018; Muhuri, et al., 2019; Eurostat, 2020). 40 experts were involved who participated in the analysis rounds. Individuals with solid expertise and sustainability skills were selected. The database used for the selection of experts was the one from the application of the questionnaire (of the 100 respondents). There were 6 segments of manufacturing industry identified based on the activity performed in Romania. These segments, the percentage and the targeted directions are presented in Table 1.25.

Table 1.25. Researched Segments of Manufacturing industry

Segment of Manufacturing industry	Number of Firms (and % of the Sample Firms)	**Directions evaluated by experts**
Automotive	35 (35%)	Domain experience Involvement in innovation Involvement in sustainable development Involvement in strategic management
Production of foams, chemicals, plastics, oil	9 (9%)	
Food and beverage production	15 (15%)	

Furniture production	11 (11%)	Strategic vision
Pharmaceutical production	7 (7%)	
Other productions (metal, electronic, non-metallic, clothing)	23 (23%)	

c. Empirical experience

The concern on the sustainable development study of over 10 years and the multiple researches carried out (over 150 works) have contributed to the extension of the researches towards this model of manufacturing. The researches carried out (Cioca et al., 2019; Taucean et al, 2019; Ivascu and Cioca, 2019) have contributed to the foundation of the concept and to the identification of measures and performance indicators. They are the pillar of the development of the hierarchical framework for sustainability assessment. The author has contributed as the main author to the development of a series of researches that have advanced the field of sustainability, Table 1.26**.**

Table 1.26**.** Research by the author in the field of sustainability and innovation

Research	**Journal**	**Development**
[48]	Sustainability	Sustainable Development Model for the Automotive Industry based on in-depth interviews with 33 experts
[49]	Sustainability	Integrating Sustainability and Lean: SLIM Method and Enterprise Game Proposed - To train students as experts in sustainability and lean
[50]	Safety	Occupational Accidents Assessment by Field of Activity and Investigation Model for Prevention and Control - Identifying risks and proposing preventive and corrective measures in the direction of sustainable development
[51]	Sustainability	Risk Indicators and Road Accident Analysis for the Period 2012–2016 - Strategic framework for the sustainability of transport
[52]	Sustainability	The Evaluation and Application of the TRIZ Method for Increasing Eco-Innovative Levels in SMEs - Furniture production was tested
[53]	Sustainability	Sustainable Development and Technological Impact on CO_2 Reducing Conditions in Romania - CO_2 reduction for improving climatic conditions

National and international situation in the manufacturing industry

Manufacturing is the production of goods intended for use or sale with labor and machinery, instruments, processing or chemical or biological formulation (Cioca, and Ivascu, 2017). Finished products can be sold, through a distribution chain, to other producers for the production of more complex products or redistributed through the tertiary industry to final

consumers. In order to characterize the manufacturing, a qualitative evaluation of the existing data series in the databases of the accredited institutes is performed. To characterize the manufacturing are taken into account: the number of employees, the amount of waste generated, the greenhouse gas emissions and the level of innovation. These indicators are presented for the European Union (EU) and Romania (Cioca et al., 2019; Taucean et al, 2019; Ivascu and Cioca, 2019).

The number of employed persons in the European Union decreased to 230,356.80 thousand in the first quarter of 2019 from 231,342.70 thousand in the fourth quarter of 2018. Of the EU employees over 15% are in the manufacturing industry.

In Romania, the number of employees in industry, construction, trade and other services in 2018 was 8,197,014, and in 2019 8,249,779 employees. The employee is the person who exercises his activity on the basis of an employment contract in an economic or social unit - regardless of its form of ownership - or to private persons, in exchange for a remuneration in the form of a salary, paid in money or nature, under commission form and others (Han et al., 2013; Feniser et al, 2017; Li et al., 2020; Đurđević, et al., 2020). Figure 1.22 shows the main areas of activity and the number of employees for the period 2017-2019.

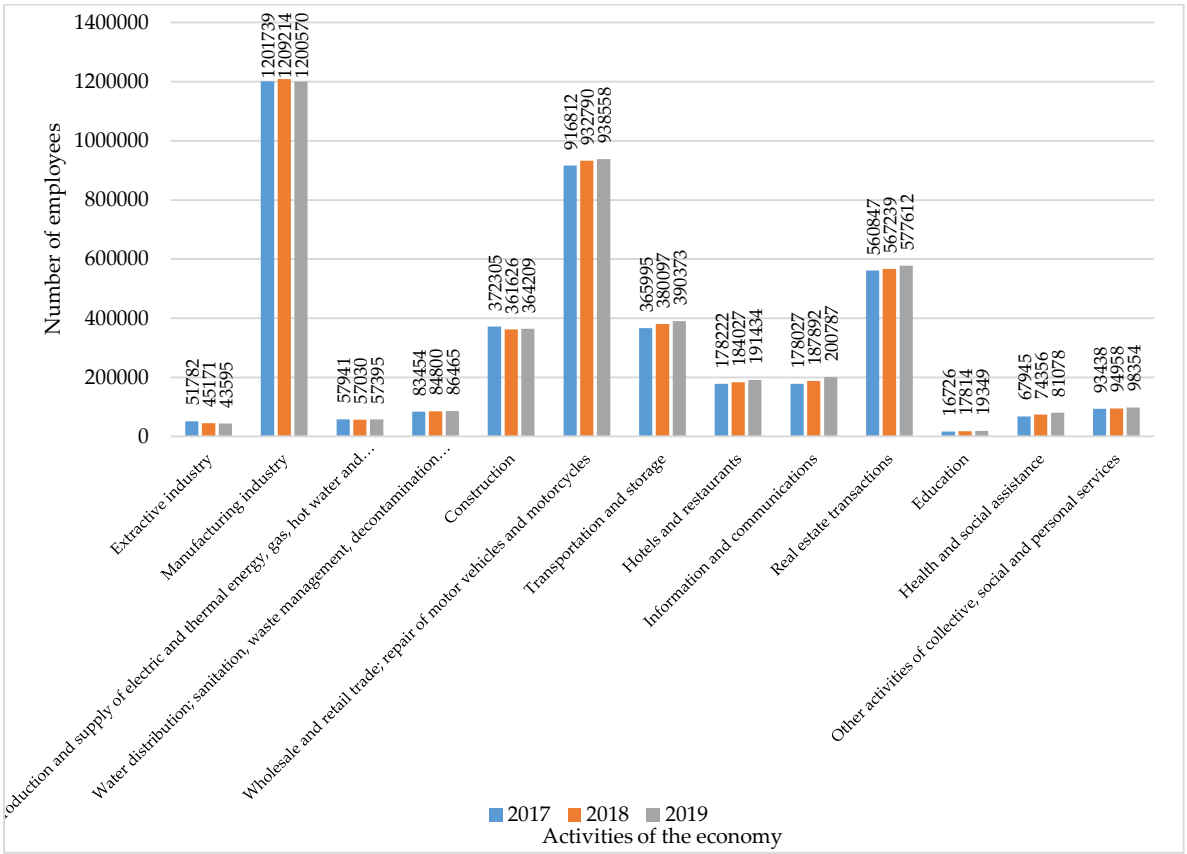


Figure 1.22. Situation of the number of employees in the main activities of the Romanian economy in the period 2017-2019

Source: National Institute of Statistics, 2019

From the perspective of the quantity of waste generated, at EU level there is an amount of 2,116,310,000 tons in 2016 and 2,125,300,000 in 2017. From the perspective of the countries that generate these quantities, the situation is presented in Figure 1.23. The series is presented according to the reported data (some countries have not reported the amount of waste generated). Romania generated 176,742,421 tons of waste in 2017.

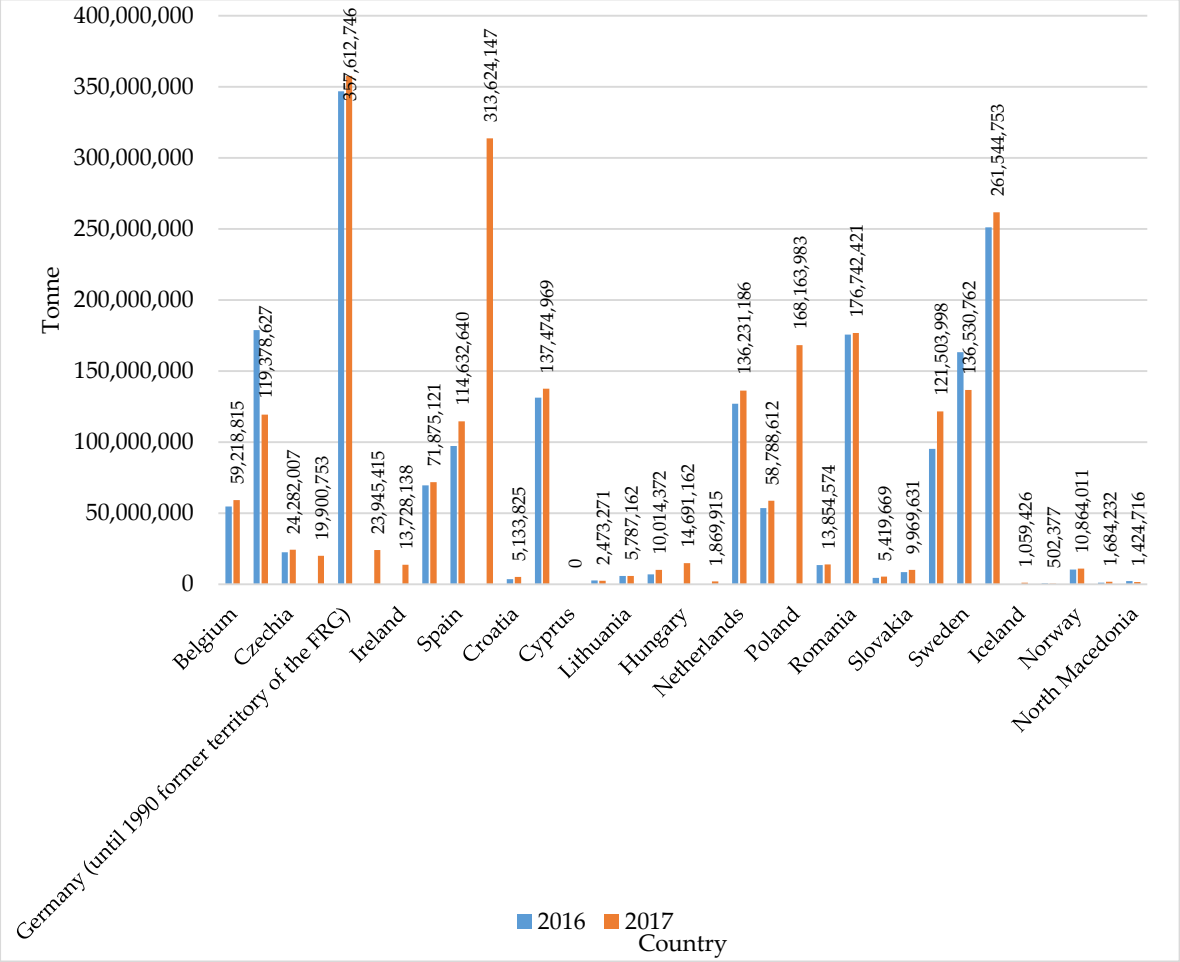


Figure 1.23**.** Amount of waste generated in EU for 2016-2017 (tons)

Source: Eurostat, 2019

Of the total amount of waste, at the European Union level, 253,440,000 tons in 2016 and 258,890,000 tons in 2017 are generated by the manufacturing industry, Figure 1.23 . The percentage of waste generated in manufacturing is over 10% of the total waste generated. For Romania, the quantity of waste generated by manufacturing is 6,727,021 tons in 2016 and 7,770,090 tons in 2017, Figure 1.24.

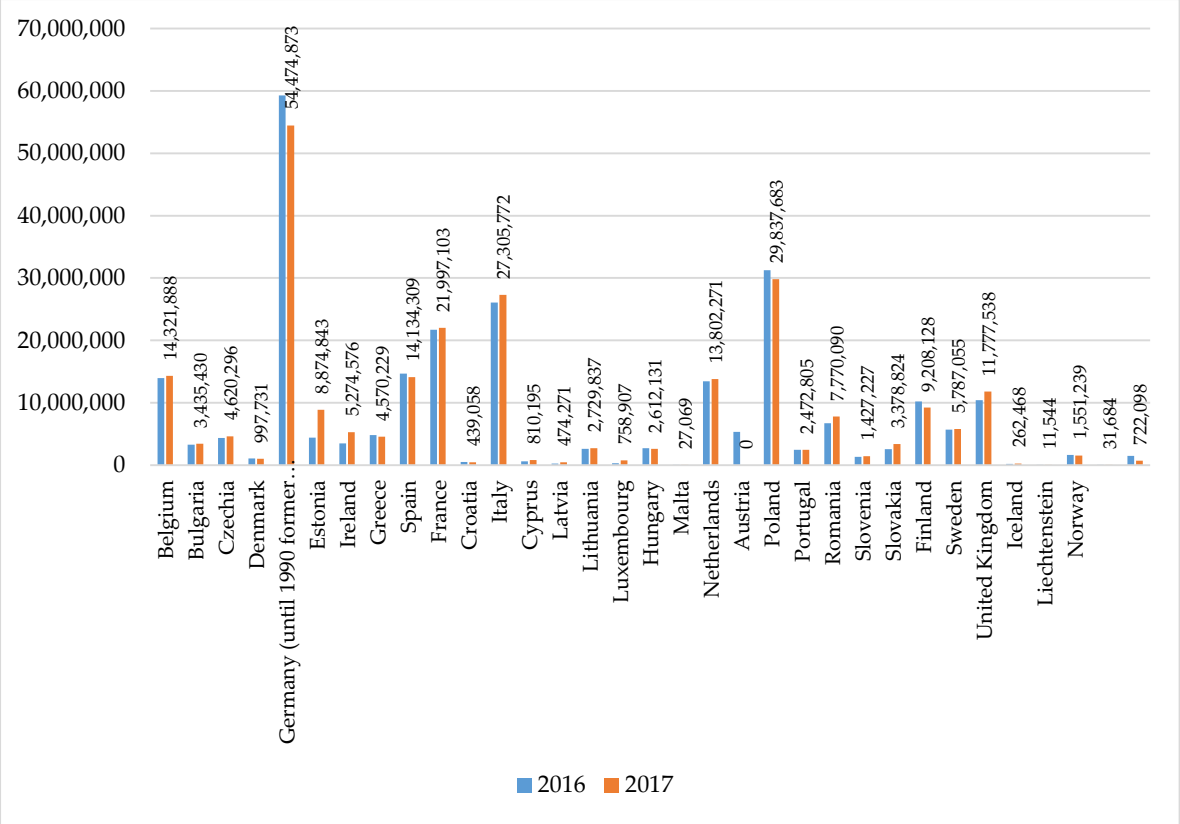


Figure 1.24. The quantity of waste generated by the manufacturing industry in the EU countries for the period 2016-2017 (tons) [45]

From the perspective of the quantity of greenhouse gases emitted, there is registered, for EU, an amount of 4,461,685.11 tons in 2016 and 4,492,127.01 in 2017. Of this quantity, over 10% is generated by the manufacturing industry. Romania generated 115,150.66 tons in 2016 and 114,811.43 tons in 2017. Manufacturing industry generated 12,836.27 tons in 2016 and 13,105.39 tons in 2017. It can be seen that over 10% is generated by manufacturing industry in Romania as well. The EU trend is also followed nationally.

Thus it can be stated that the manufacturing industry is an important economic activity, with considerable contribution in EU and Romania so that the research approach is essential in this field.

Characteristics of Industry 4.0

Manufacturing processes have a great responsibility for the high consumption of natural resources and the generation of greenhouse gases. Manufacturing is defined as "the transformation of materials and information into tangible and intangible goods to satisfy the needs and desires of the buyers (Siddiqi, et al., 2019; Henao et al., 2019; Liang, et al., 2019). The industry sector, including production, consumes almost half of the total energy delivered worldwide (Zhou, 2014). The US manufacturing absorbs more than 42% of total energy consumption. Similarly, in China, the manufacturing sector absorbs 58% of total energy consumption (Kwak, 2019). As a result, numerous efforts have been made to reduce the environmental impact of different manufacturing processes and several strategies have been

implemented to monitor, improve and control variables such as energy consumption, carbon emissions, the development of sustainable jobs (Grados, 2019) and the integration of innovative solutions (García-Arca, 2014).

Within this framework of sustainable development, Industry 4.0 appears as an industrial opportunity. The concept of Industry 4.0 began as a strategic framework for industrial production, conceived and implemented by the German government in 2011. Industry 4.0 can be defined as a combination of technologies and value concepts applicable to organizational processes. This is a general transformation using digital integration and intelligent engineering (De Angelis, 2018). Industry 4.0 imperatives are in the following directions: the preparation of an intelligent, computerized, optimized manufacturing environment, which guarantees the flexibility and high efficiency of the production and minimal impact on the environment. Therefore, approaching Industry 4.0 in the context of sustainable development is mandatory because the potential results obtained from this approach are: productivity and resource efficiency (De Angelis, 2018). For example, in researches it is emphasized that Industry 4.0: encourages digitization by offering new efficient approaches to process control, using the Internet of Things and integrating cyber-physical systems into manufacturing can solve resource and energy efficiency, and automated manufacturing concepts will increases the level of innovation and will reduce the amount of waste and waste generated. Industry 4.0 describes the progressive fusion of industrial production processes with the digital world of information technology (Kwak, 2019).

Evaluating the two approaches, sustainable development and Industry 4.0 framework in the manufacturing industry we can identify the following applications in manufacturing (Kwak, 2019). This analysis takes into account the 17 objectives and 169 goals of sustainable development (17 SDGs and 169 goals) and the definition of Industry 4.0. The entire analysis is based on studies published in the literature and are based on the needs of the manufacturing industry (see Table 1.27Table 1.27). For example, simulating different algorithms contributes to reducing poverty by proposing frameworks for improvement and identifying problems, improving living conditions, education through access to technology, identifying gaps for energy efficiency and improving conditions and outcomes for social responsibility.

Table 1.27**.** Industry 4.0 imperatives,17 SDGs, and benefits

Industry 4.0 imperatives	**Research**	**17 SDGs/169 goals**	**Applicability in manufacturing**	**Benefits**
Internet of Things	[30]	3,5,7,8,9,11,12,17 SDGs	The materials, structural elements and components of the machine are equipped with sensors and Internet connection	Process efficiency Data exchange between robots Increased production capacity Increasing the level of innovation
Radio frequency identification technology (RFID)	[31,33]	3,5,7,8,9,11,12,17 SDGs	It allows the real-time visibility of the materials and goods of the manufacturing processes	Reduces transportation errors, improves security, validates raw materials, increases the visibility of goods in the supply chain

Cognitive Computing	[34]	1,3,5,7,8,9,11,12,17 SDGs	Understanding tasks, workflows, business process logic	New cognitive technologies, scalability, productivity and quality
Cybersecurity	[35]	9,11,12,17 SDGs	Process security	Loss reduction
Cloud Computing	[36]	3,5,7,8,9,11,12,17 SDGs	Scalable business solutions	Process innovation and expansion
Mobile technologies	[37]	1,5,7,8,9,11,12,15,17 SDGs	Real-time data monitoring, collection and processing	Reduce time, streamline processes
M2M (machine to machine)	[38]	3,5,7,8,9,11,12,1317 SDGs	Communication of devices connected to the same network	Automation of devices connected to the network to improve production efficiency
3D Printing	[39]	3,5,7,8,9,11,12,17 SDGs	Attractive and efficient presentation of new concepts	New collaborations, reduction of resource consumption
Advanced Robotics	[41]	11,12,13,14,17 SDGs	Efficient automation	Reduction of waste and GHG quantity
Augmented Reality	[42]	3,5,7,8,9,16 SDGs	Testing of some products and processes in accordance with market requirements	Efficient operations by reducing production downtime, quickly identifying problems and maintaining all services and processes
Simulation	[42]	1,2,3,4,5,7,12 SDGs	The use of software to make computer models of manufacturing systems	Reducing gaps and improving production capacity

The manufacturing industry in Romania

The manufacturing in Romania is constantly growing, being one of the most important. In this industry more than 1.2 million employees work, that is 35% of the workforce in the economy (Kwak, 2019). Included are companies in the food industry, beverage manufacturing, tobacco products, textiles and clothing, wood processing, furniture, chemical industry, auto industry, pharmaceutical products manufacturing (companies with NACE code between 10 and 33). The net profit balance is 542 million euros (the difference between the total net profit and the total losses), the margin of the big factories in the local economy was 3.5% last year (De Angelis, 2018). The first positions are occupied by companies in the automotive industry, crude oil processing, road transport, the production of soft drinks, the manufacture of household appliances and the manufacture of alcoholic beverages (De Angelis, 2018). The characteristics of the Romanian market are: skilled labor force, competent in the field, low / medium level of remuneration (compared to the salary level in the European Union), the university environment open to collaborations with the industry in order to develop the required competences, adaptability, average involvement of the state authorities, capacity for expansion and globalization (Kwak, 2019). The process of production systematized for the manufacturing is shown in Figure 1.25. The definition of the process begins with the definition of the strategic

elements. The next level includes the requirements, the conditions for carrying out the processes and the current situation of the processes. The next level includes the elements related to the company's logistics, integrating the customer's requirements. Finally, we find the reverse logistics.

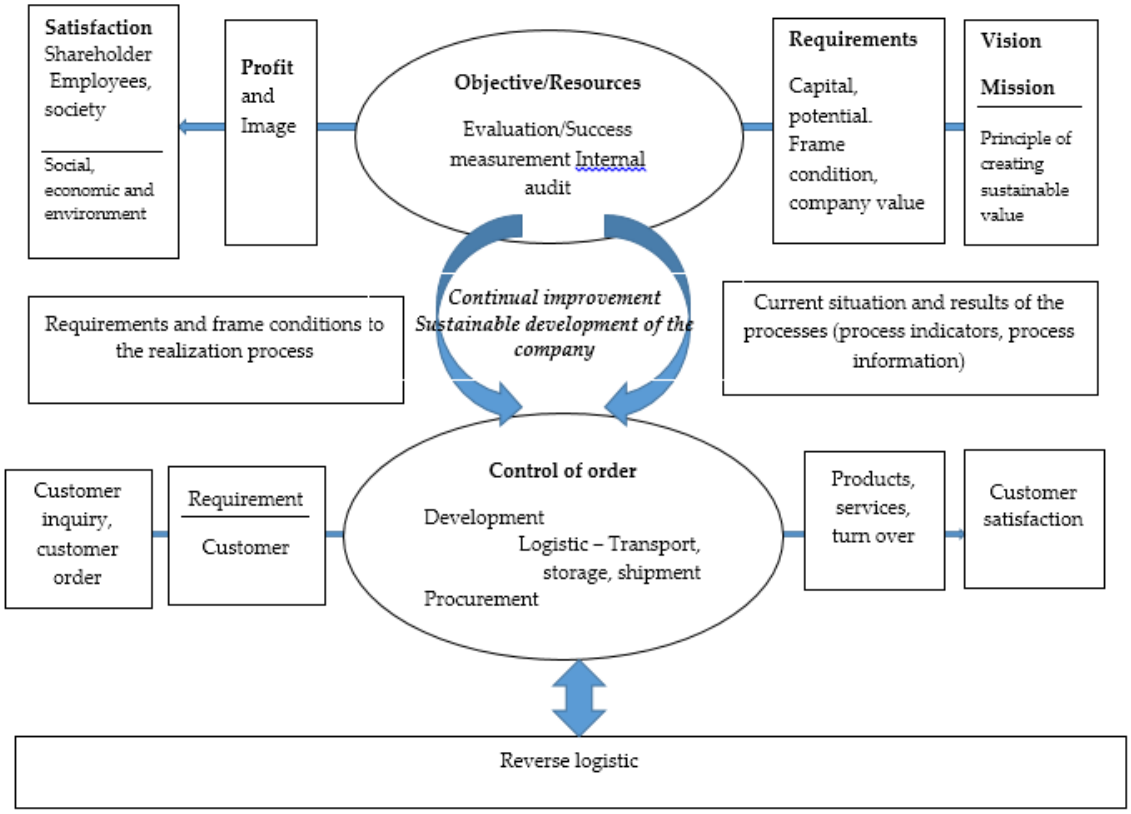


Figure 1.25. Process model for manufacturing industry

Results

This section presents the results obtained from the research. At the end of the presentation of the results, the hierarchical framework for sustainability assessment of manufacturing industry is presented.

a. Industry 4.0: characteristics, implications and proposed developments

Industry 4.0. includes the tendency of companies towards automation and data exchange in technologies and manufacturing processes that include cyber-physical systems (CPS), the Internet of Things (IoT), the Industrial Internet of Things (IoT), cloud computing, cognitive computing and artificial intelligence and other implications related to these fields (Kwak, 2019). New digital industrial technology presents a number of facilities for the sustainability of companies (Okudan, 2004; Kwak, 2019) Below are the results obtained in the research conducted with the 100 experts from the fields related to manufacturing industry.

The information is structured in Figure 1.26. The results obtained for each of the four directions are presented: company information, Industry 4.0 - Interpretation, facilitators and barriers, Industry 4.0 - Maturity, and National Technology Platform Industry 4.0. For each

investigated element, the characteristics and indicators that will be used in the hierarchical framework formation were retained.

For the first direction, *information about the company*, directions for characterizing the companies of the study respondents were targeted. Percentages were identified by major categories (as a result of responses based on a single choice from a number of variants). The second direction, *Interpretation, facilitators and barriers*, addressed a number of important elements for Industry 4.0. The respondent had multiple selections. In the interpretation of the data the percentage of the total respondents was used. The third direction, the *maturity*, allowed the respondents a unique choice based on Likert scale assessment. In the interpretation of the data the percentage of the total respondents was used. The last direction, the *National Technology Platform Industry 4.0*, allowed a single selection and the value obtained was interpreted as a percentage.

Figure 1.26. Sustainable development and Industry 4.0

Direction	Investigated Elements	Recorded Answers
Company information	Field of activity:	Automotive, foam production, chemicals, plastics, oil; food and beverage production; furniture production; pharmaceutical production and other productions
	Identification of the best-selling product	Metal article, automotive article, industry equipment, software, office furniture, women's clothing, rings production (jewelry)
	Number of Employees	1-200 employees (65%),> 200 employees (35%)
	Assessment of the level of innovation of the company (0-100)	40% - score <50, 30% [51.80], 20%> 80
Interpretation, facilitators and barriers	Identification of company practices in Industry 4.0	Automation of production processes (90%), BigData (53%), Cloud Computing (23%), IoT (43%) and digitization (45%)
	Evaluation of Industry facilitators 4.0	Cost reduction (75%), Competitiveness (63%), Need for higher control for top management (51%), demand from partners (83%), challenges of the era (53%), financial benefits (73%), Times of delivery (65%), increased customer satisfaction (53%), efficiency improvement (65%), flexibility (73%), reliable operation (81%), production interruptions (78%).
	Barriers Industry 4.0	Lack of financial resources (65%), skills (75%), supply chain dimensioning (83%), organizational structure (51%), employee resistance (87%).
Maturity	Identifying the degree of maturity	High (65%), medium (30%), low (5%)
	Evaluation of a proposed model for digital maturity that includes: strategy, technology, operations, organization and culture and clients	Medium strategy (70%), advanced (30%) Medium technology (55%), advanced (45%) Operations average (62%), advanced (38%) Organization and culture medium (57%), advanced (43%) Customers: average (51%), advanced (49%)
National Technology Platform Industry 4.0.	Evaluation of the national platform Industry 4.0	They use the platform (24%), do not use and did not know (76%). No company is a member
	Assessment of the importance of the actors of the Industry 4.0 platform: government, universities and research institutes, users-companies of Industry 4.0 and suppliers of Industry 4.0	Government - medium (75%), advanced (25%) Universities and research institutes - medium (15%), advanced (85%) Users - companies in Industry 4.0 - medium (5%), advanced (95%) Industry suppliers 4.0- medium (3%), advanced (97%)
	The level of resistance to digitization Transforming the company into the digitalization era	Human resources (57%), financial (33%) 100% follow the transformation of the company

b. Indicators of sustainable development on the dimensions of the triple baseline

To identify the performance measures and sustainability indicators, the Delphi method was used, with 3 rounds of discussions for defining their importance. The results of the first round are presented in Table 1.28. For the evaluation of the targeted directions the following were used:

a. Experience - the lowest level recorded in the 40 experts is presented

b. Involvement in innovation - the arithmetic mean is calculated

c. Involvement in sustainable development - there are categories of indicators presented

d. Involvement in strategic management - there are categories of indicators presented

e. Strategic vision - there are categories of indicators presented

For each segment of manufacturing industry, the indicators that are not found in the previous segments are filled in.

Table 1.28. Directions evaluated by experts

Segment of Manufacturing industry	**Directions evaluated by experts**	**Response**
Automotive	Domain experience:	> 15 years
	Innovation	> 70% (New technologies, big data, simulation, cloud computing for processes)
	Involvement in sustainable development:	Economic performance indicators, Continuous Improvement, external interaction, digitalization, waste management, operations management, loss reduction, and occupational health and safety policies.
	Involvement in strategic: management	Resource management, Activity planning, Globalization, Improving the capacity for regeneration, process quality, financial indicators
	Strategic vision:	Process planning, Continuous learning, knowledge management, corporate social responsibility
Production of foams, chemicals, plastics, oil	Domain experience:	> 21 years
	Involvement in innovation:	> 78%
	Involvement in sustainable development:	Hazardous waste management, water protection and other elements
	Involvement in strategic management:	Collaboration with other institutions for research and development
	Strategic vision:	Sharing knowledge, copyright
Food and beverage production	Domain experience:	> 30 years
	Involvement in innovation:	> 56%
	Involvement in sustainable development:	Packaging management, customer information
	Involvement in strategic management:	Global distribution and collaboration
	Strategic vision:	Increased the capacity of Industry 4.0 implementation
Furniture production	Domain experience:	> 25 years
	Involvement in innovation:	> 62%
	Involvement in sustainable development:	Waste reuse, reverse logistics, customer created value, redesign
	Involvement in strategic management:	Defining local and national strategies

	Strategic vision:	Penetration of a new market segment
Pharmaceutical production	Domain experience:	> 18 years
	Involvement in innovation:	> 87%
	Involvement in sustainable development:	Agile manufacturing, reverse logistic, collaboration with universities, product specifications
	Involvement in strategic management:	Customer management, globalization, waste reduction
	Strategic vision:	Merging with international companies
Other productions	Domain experience:	> 5 years
	Involvement in innovation:	> 64%
	Involvement in sustainable development:	Supplier management, sustainable jobs, eco-design, redesign
	Involvement in strategic management:	Voice of customer, sustainable product
	Strategic vision:	Annual reporting

After identifying all the measures and indicators in round 1, they are reviewed in round 2 to develop the final report. The whole approach is coordinated by the facilitator. These indicators were ranked on the 5 levels of importance. Each level includes the indicators and measures related to the three basic lines (social, economic and environmental). A structural self-interaction matrix (SSIM) was used for the selected elements from round 2. The report in round 3 was accepted by all experts (40 experts) of the target group. The definition of the hierarchical framework for sustainability assessment of manufacturing industry is presented in Table 1.29**.** All indicators agreed by experts were divided into categories on the three dimensions of sustainability. These categories were allocated on 5 levels. Their levels and importance were determined by experts in the field during the rounds of the Delphi method. Shareholders believe that any implementation must be approved and accepted by them and that they will not finance techniques and technologies that are not profitable. Everyone appreciated that this is the first level of evaluation.

Table 1.29. Defining the hierarchical framework

Level	Identification in the manufacturing industry	Social dimension	Economical dimension	Environmental dimension
Level 5	Reverse logistic (recovery of raw materials)	Continuous learning	Supplier management	9R
Level 4	Customer satisfaction	Customer management	Resource optimization	Environmental health and safety
Level 3	Life cycle assessment (product, services)	Agile	Sustainable maintenance	Design for environment (lean, agile, manufacturing)
Level 2	Process of the logistics chain (development, procurement, transport, storage, shipment)	Sustainable workplaces	Knowledge and quality management	Industry 4.0
Level 1	Shareholders (satisfaction, requirement shareholders, profit and image)	Strategic element	Financial improvement	Continuous improvement

c. Proposed conceptual hierarchical framework for sustainability assessment of manufacturing industry

For each level, indicators were defined for each dimension of sustainability. The indicators are identified based on market research (Industry 4.0) and Delphi analysis. Each level records a score calculated as the arithmetic mean of the scores recorded. For each indicator, the evaluator gives a grade from 1 to 5, depending on the degree of implementation (1 = not implemented and 5 = fully implemented). The final report after measuring the performance on sustainable development will include the score obtained on each level for each dimension, Figure 1.27. At the end of the evaluation, the value of the levels is calculated as the arithmetic mean of the 5 evaluated levels.

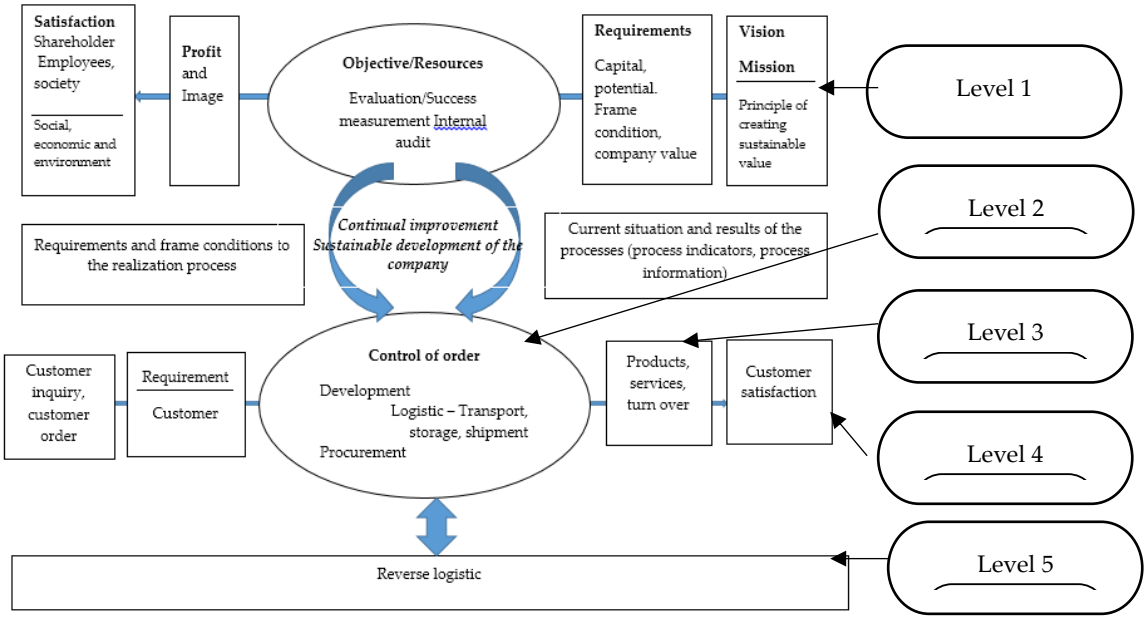


Figure 1.27. Hierarchical framework for sustainability assessment of manufacturing industry

d. Empirical testing

The result of the empirical testing is shown in Figure1.28. It can be observed that if the indicator level is lower than 2 it returns to the initial phase for level improvement. The value of the total score registered for a company highlights the involvement in the sustainable development. If the value L is less than 10, then the company is at the limit of the level of sustainability and it is recommended to improve all indicators of the 5 levels. If the value is between 10 and 15, the involvement is average, and the recommendations refer to the implementation of some directions of Industry 4.0 in order to increase the level of competitiveness. If the score value is greater than 15 then the situation of the company is favorable.

This hierarchical model was conceived in the form of a continuous loop. The evaluation of a company does not go further if the evaluation of the level indicators does not exceed 2. If the value is not 2, it returns to the previous level to improve certain indicators that have received low scores. When each level is satisfied, the end is reached by measuring the company's implications. At each level, depending on the value, different recommendations are received.

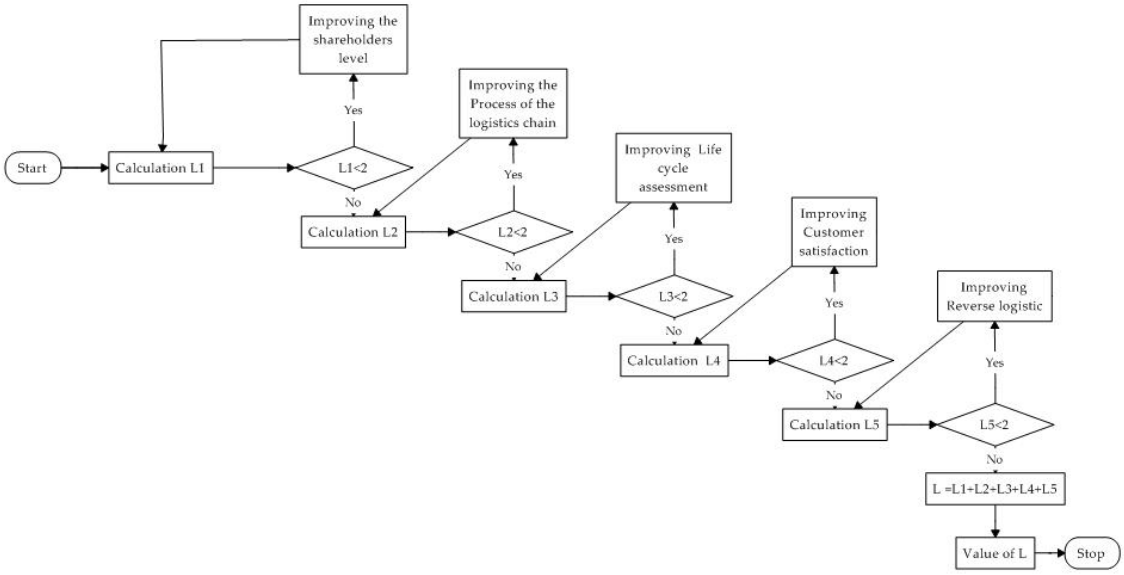


Figure1.28. Empirical evaluation based on the proposed hierarchical framework

e. Validation and future research approach

The validation was performed on a company in the automotive industry, and the results obtained are presented in the following process. For the evaluated company, the 5 levels were completed. For each level, the value being less than 2, a series of recommendations were received which are presented in Table 1.30. The whole evaluation was based on the algorithm presented in Figure1.28.

Table 1.30**.** The results obtained during the evaluation

Level	Improvements implemented following empirical testing
Level 5	Application of 9Rs in any situation of the company
Level 4	Evaluation of requirements regarding international standards
Level 3	Improving the materials used and recovering the value at the end of the life cycle
Level 2	Imposing improvements regarding Industry 4.0
Level 1	Involving shareholders in establishing financial indicators

Following the research conducted, various aspects related to the need for sustainable development and Industry 4.0 can be discussed. From the perspective of Industry 4.0 it can be seen that not all companies in Romania have accessed the national platform for Industry 4.0. Among the most important facilitators of Industry 4.0 are: cost reduction, competitiveness, demand for partners, financial benefits, flexibility, reliable operation, production interruptions. Barriers mainly refer to the lack of financial resources, the competencies, the dimensioning of the supply chain and the resistance of the employees.

From the perspective of sustainable development, following the application of the Delphi method, a series of measures and indicators have been identified that contribute to the assessment of sustainable development and to the proposal of improvement measures.

The proposed model takes into account the imperatives of Industry 4.0 for manufacturing, the objectives and indicators of sustainable development. 5 levels of evaluation are developed to systematically identify the measures required to improve the company's situation. Compared to existing methods, the present model reaches a final form during critical rounds of brainstorming analysis. These were performed during the Delphi method.

A 5-level hierarchical model was developed starting from the interests of the shareholders to the reverse logistics. For each level the impact of the indicators is calculated, and finally the total value. A value of a level below score 2 requires a review of the company's behavior in those directions. Finally, the company's position towards sustainable development is obtained.

Following the test, a series of improvements of the initially proposed conceptual model were obtained. These improvements refer to: improvements implemented following the empirical testing, the application of the 9Rs in any situation of the company, the evaluation of the requirements regarding the international standards, the improvement of the materials used and the recovery of the value at the end of the life cycle, the imposition of improvements regarding the Industry 4.0 and the involvement of shareholders in establishing financial indicators.

The proposed model advances the level of knowledge in the field by the fact that it has really identified the imperatives of industry 4.0 and develops a model in rounds of debates with experts in the field of manufacturing. This model is not a theoretical one, but one approved by the most important 40 experts (they were chosen according to the top companies). The model is applicable to every industry because the evaluation is done by semi-quantitative assessments by competitiveness experts. The reference for each field is represented by the most important company from the top of the companies (made for the selection of the interviewed companies).

A set of the proposed frameworks (Cioca et al., 2015) propose evaluations based on checklists that present certain limitations from the perspective of covering all organizational levels. These indicators were established on the basis of the specialized literature, without a multi-round discussion with experts in the fields of activity.

The hierarchical model is valid and can be extended to other industries. The banking field is targeted because it is a field that has major implications in the economic and social dimensions. At the same time, this model will also identify the disruptive factors that may occur (we expect that the medical factors may affect the functioning of a system).

Conclusions

This section proposed a five-level framework for assessing manufacturing sustainability. The definition of these five levels offers an important stage in terms of production as well as sustainability in the manufacturing sector. The research focused on the two important directions for the competitiveness of the business environment: the sustainability and the digitization of the industry. Only experts from the manufacturing industry were involved in the research and

the experience of multiple previous researches was used. At the same time, the theoretical frameworks developed previously contributed to the foundation of the proposed and tested framework.

To characterize the industry, existing data series from accredited institutions were used. These influenced the selection of the manufacturing for the carried-out analysis. The use of market research and the involvement of experts in the research undertaken have contributed to the outline of the proposed framework. Empirical testing has led to the completion of the proposed framework that has been improved and can be transposed into an online platform using databases and Web programming facilities.

Future directions will also extend the model to other industries. Barriers encountered during the research refer to the factors that contribute to changing the conditions of the business environment. The research was carried out during 2019, and at the end of it we started structuring and analyzing the data obtained. Since 2020, a number of factors have begun to appear that affect the economic conditions worldwide (the virus that spreads worldwide). These factors completely change the behavior of industries. The limitation of the study refers to the fact that the Romanian manufacturing characteristics are taken into account for research. In Romania, there is a need for the development of a model and that is why I focused only on these characteristics.

Sustainable development of organizations involves streamlining the use of resources and reducing the long-term impact on the environment. In this sense, there can be no sustainable development of organizations if the risks are not assessed. The next section addresses risk management in sustainable organization.

1.4. Risk Management

1.4.1. Investigating the relationship between risk management and sustainable development management

Sustainable development is a complex and debated concept in the literature. Sustainable development of the organization involves analyzing how businesses can engage fully and real in adopting this concept in the processes developed by each company. In talking about integrating a model of sustainable development, it is necessary to investigate the risks of organizational processes. So between sustainable development and risk management there is a direct relationship, being a concept that contributes to organizational innovation. The Concepts, risk management and sustainability development, are adjacent to international standards and norms. The sustainable development approach becomes complex if the main objective of the organization is innovation. This section presents a review of literature, the relevant to risk and sustainability standards, and a software tool for analyzing risk and sustainability. The principle of the proposed approach is systematization and integration of legal requirements on risk and sustainability in an organization assessment tool to achieve the enterprise objectives and the coordination of innovation.

The need of the present economic environment directs the organizations toward sustainable development. In a global and complex economic system there are a number of "disturbers".

These perturbations generate a number of risks that must be treated. The organizations are thus subsystems of the economic environment (the economic system), for which to assess the inputs and to report the outputs. This systemic thinking of the business environment has led to the development of a risk assessment platform that contributes to sustainable development and innovation management.

The risk and the sustainability are a "buzzword" both nationally and internationally. Integrative assessment of these concepts becomes an interesting and complex framework that is discussed in this section. The two concepts, risk and sustainability are assessed and analyzed through an innovative approach that contributes to a real and sustained assessment of the enterprise in terms of current technology and international alignment (Izvercian, et al., 2014).

Any activity within an organization involves risk, as any daily activity in our life involves a risk. The importance of this concept lies in the fact that besides the negative associated connotation (hazard, damage, disaster), it involves an opportunity also. These opportunities lead to the development of new processes, new business connections and thus to innovation. In fact, assessing risk in the organizational processes and implementing a sustainable development model, the organization is "moving" towards competitiveness and innovation. Certainly, between risk management and sustainable development there is a relationship of proportionality. By evaluating this relationship it is seen that risk and sustainability are dependent and proportionate concept.

Risk Management Concept

Prior to 2000, all publications and report of risk management were using the negative connotation of risk, the term being associated with danger (Olso et al., 2010), trouble, and loss (Narver et al., 2002). After this date, the literature presents risk as the combination of opportunity and threat (Hillson, 2010) or as multi- dimensional measure of exposure to imprecise losses (Haimes, 2005). Another theory states the complex implications of this concept, as a probability, a mathematical quantity that can be measured, calculated and estimated. Risk is not a malicious concept, risks are essential to the progress of a system, and failures are key elements of learning (Chapman, 2011). The ISO Guide 73 defines risk as the "effect of uncertainty on objective" (Cioca et al, 2009). Process by which the risk is identified, analyzed, evaluated and treated is materialized in risk management. In (Caijie, 2013) stated that "Through risk management functions, we can facilitate the aggregation, transactions and avoidance of the risk.

Risk management process is based, as any management system the four-steps (PDCA: Plan, Do, Check, Act; and then modified in PDSA: Plan, Do, Study, Act), that is continuously repeated until the risks have an acceptable level: planning, risk identification, risk assessment, mitigation and tracking (Begun, et al., 2014). Risk management is defined as a process; it is a continuous process and is "attacked" by perturbations and legislation. To solve the first disturbing element, the perturbations are taken into account in every new organization hazards assessment. To align to the legislation, the second possible disturbing element, the risk

management process includes the requirements of applicable standards on this concept. So the systematization of this approach is done in Figure 1.29.

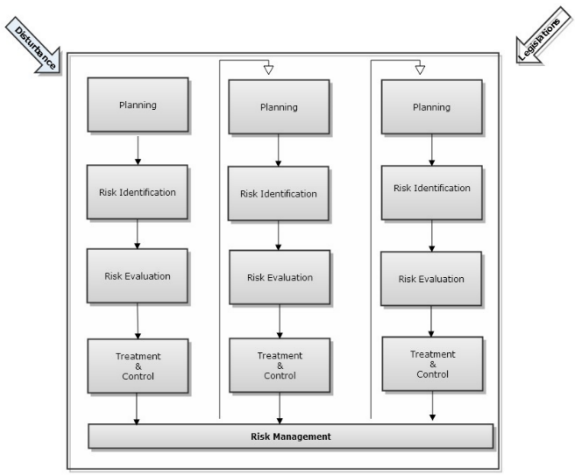


Figure 1.29. Risk Management Process

Risk management is an organized process designed to achieve the objectives. It is important to identify risks through an ongoing process and they should be monitored and also the new risks have to be relevant. Technic and technology is developing extremely quickly so the characteristics and risks of each company should not be ignored. Systemic vision of the stages of risk management contributes to optimal integration of methods and techniques for hazard identification and risk analysis in the evaluator process.

Relevant standards and other norms

By definition, according to ISO / IEC Guide 2:1996, the standard is defined as a document, established by consensus and approved by a recognized body providing for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed to obtain the optimum degree of order in a given economic context. In the current context when sustainable development and risk management have become a necessary condition for the development of the optimum competitive advantage, businesses must align with European requirements and this is possible through the implementation of European standards. International standards add technical, technological, economic, social and environmental benefits. They help to harmonize technical specifications of products and services leading to more efficient industry and eliminate barriers to international trade. International standards contribute to consumer confidence, to the development of safe, effective and of good quality products (Gopalakrishnan et al., 2014).

Therefore, a standard is a document that prescribes technical requirements, specifications, guidelines or characteristics that can be used consistently to ensure that materials, products, processes and services are fit for their purpose.

The process of certification of management systems is voluntary and international standards work in the form of guides. The validity of a certification is three years and contributes to increasing organizational competitiveness and sustainable development.

The stages of the implementation and certification process of a management system include the following main steps: (a) completing and forwarding the initial information about the organization (internal and external information); (b) designation of the audit team (auditors and / or technical experts); (c) preparing the audit plan and verifying the documents required for the audit; (d) conducting the assessment audit; (e) drawing up the audit report; (f) assessing the audit report and taking the decision to issue the certificate; (g) surveillance audit I - 12 months after the issue of the certificate; (h) surveillance audit II - 24 months after the issue of the certificate; (i) recertification audit - 36 months from initial certification to ensure continuity of the process (Siva et al., 2016).

Management systems are compatible, so for example, ISO 14001 is compatible with ISO 9001, OHSAS18001, ISO 27001, ISO 31000. The ISO 9001 standard contributes to improving the quality of products, contributing to their sustainability and production efficiency. ISO 14001 contributes to reducing the negative impact of organizations on the environment. Therefore, this standard contributes to the sustainable development of organizations. Safety and health at work are mandatory criteria for the sustainable development of organizations (Rada and Cioca, 2017). This part is covered by OHSAS 18001. Information security, ISO27001, leads to an increase in information security. SA 8000: 2008 and ISO 26000: 2010 standards refer to the social responsibility of organizations. These two standards have almost identical requirements, with the difference being that SA 8000: 2008 does not provide specific guidelines on environmental protection, organization involvement in the local community and concerns about the organization's customers. ISO 26000: 2010 and SA 8000: 2008 are the process of managing stakeholder relations, social responsibility and common interests, as well as improving relationships with local communities (Moraru and Babut, 2014; Sukitsch et al., 2015). According to the model of Porter's five forces, businesses are affected by all the forces that act on them and that they operate according to the principles of responsible social behavior. They are integrated into the business strategy and guarantee an increased competitive advantage. In accordance with ISO 26000: 2010 guidelines, it is defined by seven principles of social responsibility that include: accountability, transparency, ethical behavior, respect for stakeholder interests, respect for the rule of law, respect for international standards of conduct and respect for human rights. And this standard also contributes to achieving the goals of the social dimension of sustainable development. ISO 45001 is the new international standard for Occupational Health and Safety. This standard is similar to OHSAS 18001, but the new ISO 45001 standard adopts the superior framework of standardization in the form of other international standards (ISO 9001, ISO14001) (Starzyńska, Hamrol, 2013; Darabont et al., 2017; Babut and Moraru, 2018).

Through a review of the literature, the relevant families of standards and norms for risk management and sustainability development are: ISO 9000, ISO 14000, OHSAS 18000, ISO 26000, ISO 31000 and ISO 50000. Implementation of the requirements of these standards in organizations contributes to sustainability development and real evaluation of risk. The frameworks of these standards are the fundament of the model of sustainable development and of the developed platform. Benefits analysis of these standards is shown in Table 1.31.

Table 1.31. Evaluation of relevant standards and other norms

ISO	Description	Benefits
SA 8000 – Social Accountability	The standard addresses issues that include work and human resources.	Improves the public image Improve the company's image for participating in public auctions Increasing engagement and dialogue with employees Improving inter-functional collaboration Improve collaboration in the supply chain Treatment of employees. ethically and in line with global standards Improves the management and performance of the organization's supply chain It builds, develops and strengthens the loyalty of all stakeholders
ISO 9000 (Quality management) (Pawliczek, et al., 2013), (ILO, 2010)	Provides guidance to organizations for achievement of sustained success through a quality management approach.	Improve employee motivation, awareness and morale. Reduce waste and increases productivity. Create a more efficient, effective operation. Improve their operational efficiency
ISO 14000 (Environmental Management Systems) (ILO, 2009)	A poor environmental record can quickly damage an organization's reputation with customers and investors.	Awareness of human impact on the environment. Acceptance of responsibility for those impacts The expectation that harmful impacts will be reduced or eliminated. The placement of responsibility for environmental impacts upon all members of the community
OHSAS 18000 (Occupational Health and Safety) (ILO, 2010)	Safe working conditions.	Health and safety at work Prevention of accidents and incidents Efficiency and cost reduction Obtaining security for customers and partners
ISO 26000 (Social Responsibility)	Promotes sustainable development on health and safety and international norms of behavior.	Contributes to sustainable development, including health and the welfare of society. Takes into account the expectations of stakeholders. Is integrated throughout the organization and practiced in its relationships (ILO, 2010). Improves the public image Improve the company's image for participating in public auctions It contributes to the integration, implementation and promotion of socially responsible behavior throughout the organization Improves organizational policies and practices in the sphere of influence

		Identify and involve stakeholders Communicating engagements, performance, and other social responsibility information
ISO 27001:2013 Security of Information	Management system that helps manage the organizational security of information assets	Increase the level of confidentiality of data Availability of information The accuracy of the information Improving the reliability and security of systems and information Improving stakeholder confidence Increase business sustainability Meeting customer requirements Improving management processes and integrating with organizational risk assessment strategies
ISO 31000 (Risk management) (ILO, 2010)	Identifies opportunities and minimizes threats related to environmental, financial and safety risks.	Organizations need to find an acceptable balance between risks and returns Risk management needs to be embedded in the organization's procedures and culture improving operational efficiency and effectiveness; Strengthening organizational resistance Improves the public image Improve the company's image for participating in public auctions Increasing competitive advantage through risk management Increasing the awareness and understanding of the organization's risks Correctly addressing these risks Correctly mapping the risks identified in the organization's risk criteria and tolerance; Increase the level of trust of stakeholders Opportunities developed for new strategies, technologies and innovations Better organizational strategy due to risk control Identify new business opportunities
ISO 50000 (Energy management) (Gopalakrishnan, et al., 2014)	Continuous improvement of energy performance	Increase energy cost savings for the organization by reducing energy costs Improve operational efficiencies and maintenance practices Improve the company's image for participating in public auctions Develop a more efficient energy use policy within the organization It contributes to the setting of objectives based on energy efficiency It helps to understand and make decisions about energy consumption Measures results obtained

		Continuous improvement of energy management Gaining trust in partners

Based on these three areas: sustainable development, risk management and relevant standards, it is develops the proposal. All these elements contribute to the objectives achievement and enterprise innovation. Between the three directions: sustainable development, risk management and relevant standards is developing a bidirectional relationship of different proportionality depending on the activities of the organization. This relationship can be described in Figure 1.30.

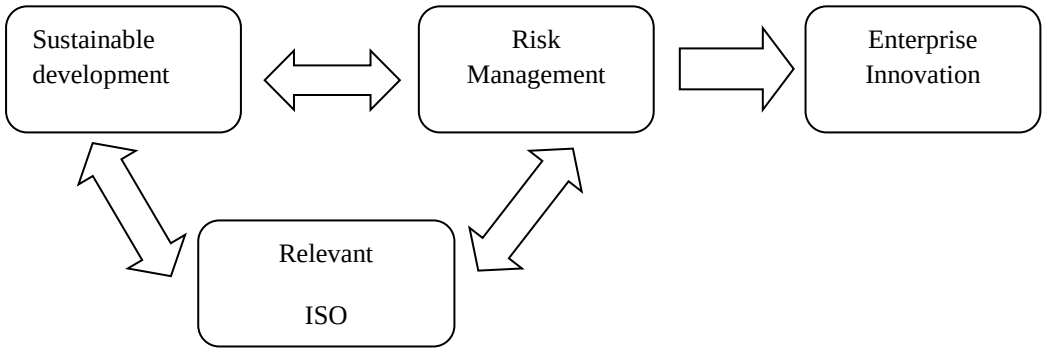


Figure 1.30. The relation of sustainable development – risk management – relevant standards

Implementation of international standards leads to a number of benefits for the client as well. These relate to increasing product quality through improved communication. These benefits are presented in the knowledge map below, Figure 1.31. These benefits include: improving safety, increasing product quality, increasing confidence, increasing the quality of air, improving security, reducing environmental impact and other.

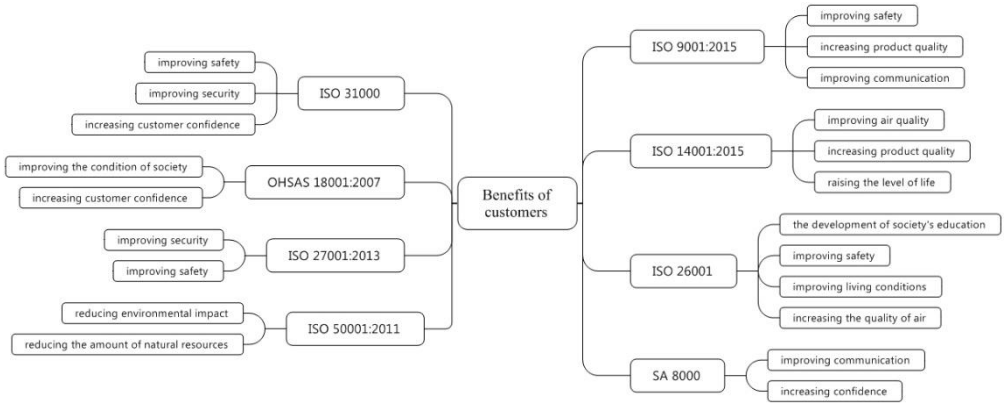


Figure 1.31. Benefits of customers following the implementation of international standards

Adopting international standards helps improving organizational activities, maximizing opportunities and minimizing losses. International standards are the category of instruments used by organizations to improve their capacity to engage in sustainable development.

Description of the key elements of SD and ISO standards

This part aims to present the key elements describing the two concepts: sustainability and management systems. The SD implications for each keyword are presented, by the author, and then the features are identified from the perspective of international standards, Table 1.32

Table 1.32. Key element of sustainable development and ISO standards perspective

Key element of SD	Implications in SD	Characteristics identified from ISO standards perspective
Effective management	SD emphasizes good management at all levels of the organization.	Standards by definition mean effective management, following the basic PDCA steps. It focuses on managing relationships with stakeholders.
Vision, mission, and objectives	Sustainability follows the vision set by stakeholders. It also requires the establishment of mission and objectives.	Managing these systems takes into account the organization's vision. The organizational objectives are pursued throughout the standardization approach, being systematically assessed.
Stakeholderi	Sustainability focuses on stakeholder engagement in activities.	Standards adopt stakeholder approach on the issues covered by each standard.
Triple bottom line (economic, social, environmental)	Sustainability implies a balance between the three dimensions: economic, social and environmental. Involves activity and indicators in each dimension. Reporting on sustainability leads to the assessment of indicators for each responsibility, in relation to the last reporting.	International standards address different directions of action, depending on the typology of each: quality (referring to the economic and environmental dimensions), environment (referring to the environmental dimension), energy (referring to the economic, social and environmental dimensions) technology (referring to the economic, social and environmental dimensions), social (referring to the social dimension).
Systematic approach	Organizational capacity for SD requires an approach to all organizational activities, from vision, managing activities to monitoring and control.	Standards require a systemic approach to the organization's activities. It analyzes and evaluates the data and information received from the monitoring and measurement processes carried out.
Strategic management	The commitment to sustainable development refers to a long-term horizon, taking into account the elements of strategic management.	Strategic management starts from vision, mission, and objectives, and controls the effectiveness of the activities. The certifications are carried out for a period of 3 years, and the

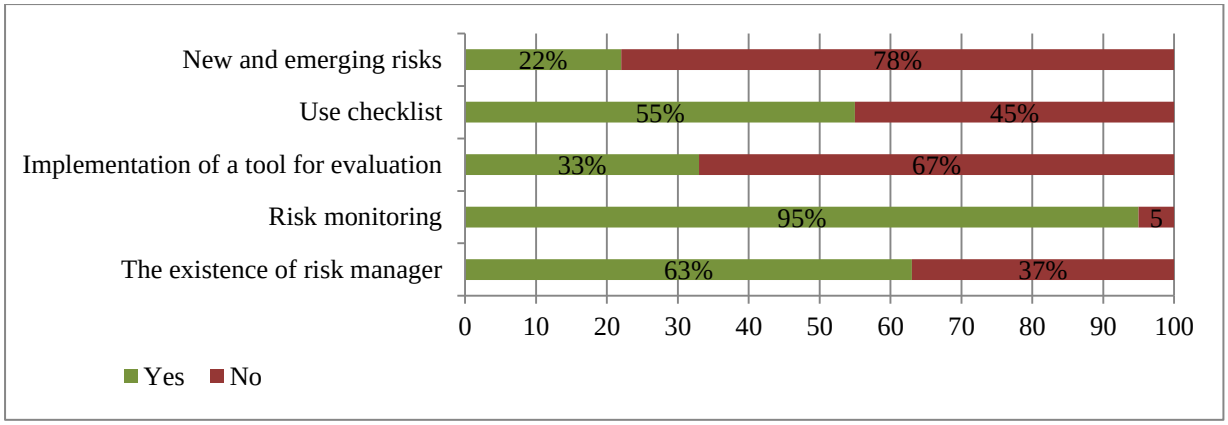
		elements of the strategic management are carefully monitored.
Innovation and learning	Lifelong learning, innovation and technology are elements addressed in sustainable development.	International standards can contribute to the emergence of new opportunities. These opportunities can lead to innovations and lifelong learning.
Opportunities	The implementation of new and innovative tools contributes to the emergence of organizational opportunities.	Standard management can lead to the identification of new opportunities.
Increase involvement	The organization is increasing its involvement in social responsibility activities in particular.	International standards help to increase stakeholders' involvement in the areas targeted by the organization.

Organizations are constantly looking for solutions that can improve their business, streamline their operations, and optimize their business performance. In the business environment, organizational success depends on the development of competitive advantages and profitability. At the same time, good corporate governance would enhance organizational competitiveness. Sustainable development is at the centre of business and academic research. Sustainability can also be accessed by organizations in different areas of activity. Organizational involvement in corporate sustainability can support long-term business success and can contribute to improving people's lives. Multiple existing tools can contribute to organizational sustainability.

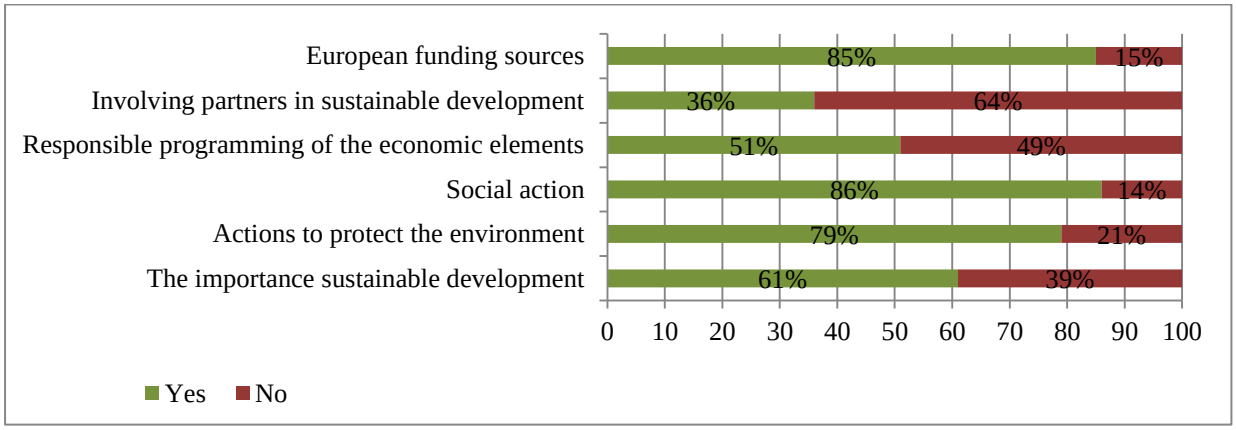
Based on the implementation of this relationship it is obtained the organization report on the current state of risk management, sustainable development and opportunities. This relationship was simulated on 101 organizations in Romania to standardize how these organizations are involved in the three directions.

The actual stage of organizations in Romania regarding sustainable development and evaluation of risk in organizations

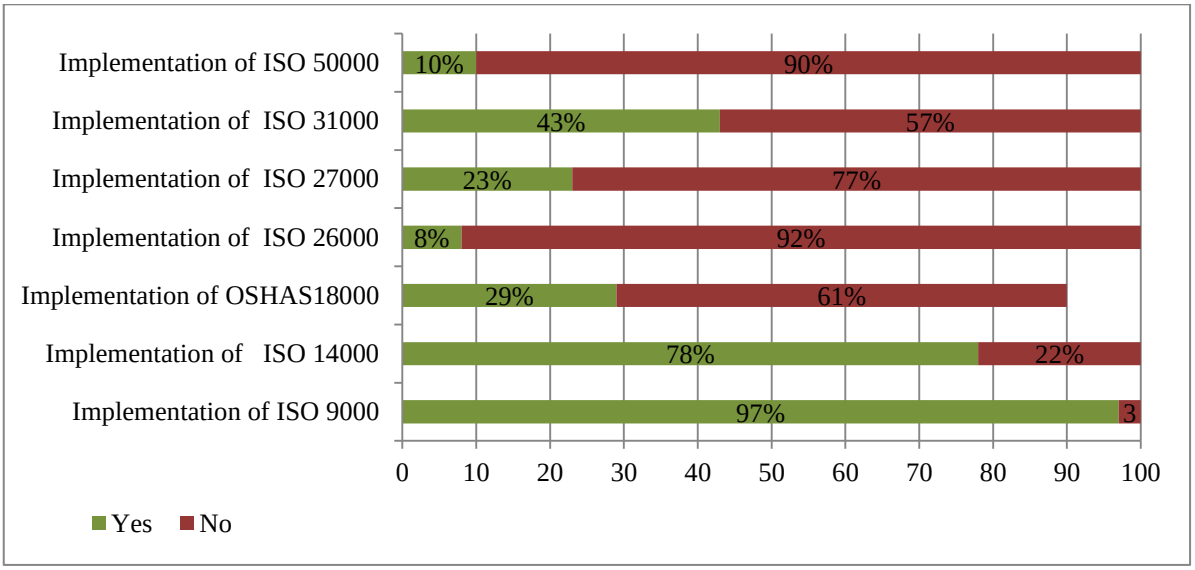
In order to investigate the actual stage of organizations in Romania regarding sustainable development and evaluation of risk in organizations, a questionnaire was developed and applied to 101 organizations in various fields. The present research integrates elements of sustainability, risk assessment and international standards. These three directions are analyzed in the three sections of the questionnaire: risk management, sustainable development and ISO, Figure 1.32 (a), (b), (c).



(a) – Risk Management Section



(b) – Sustainable Development Section



(c) – Relevant Standards Section

Figure 1.32. Results regarding risk management, sustainable development, and relevant standards

The three sections of the questionnaire is the relationship described above. Therefore, it can be seen that there is a direct proportionality between the three sections: risk management, sustainable development and relevant standards. It can be argued that those organizations that fully engage in risk and sustainability assessment implement relevant standards associated to these two concepts. It supports the idea, according to which the organizations that evaluate the risk and are involved in sustainable development are interested in aligning with the related international standards. A globalization of the market is desired, so the relationship is confirmed in Romanian organizations. Evaluating results from research it can be concluded that a substantial fraction of the surveyed enterprises addresses the implications of sustainable development. Also, in most cases there was an overlap of the concept of sustainable development with environmental protection actions. Therefore, the companies do not differentiate, yet strict environmental implications compared to the complexity of sustainable development of the organization. Interviewing the target group's involvement in the use of specific tools in risk assessment, revealed a high level of interest and implementation of such tools/platforms. The organizations emphasize the need for optimal evaluation, so that the existence of the risk manager is a condition, especially in medium-sized, large and very large enterprises. The research revealed a number of new and emerging risks that were not considered in developing this risk assessment tool. The results obtained from this research will be used to optimize the developed platform.

Enterprise innovation – The model proposal

After establishing the relationship between the three areas: risk management, sustainable development and relevant standards, the author developed the model proposed for the development of enterprise in the innovation direction. The proposed integrated approach, using risk management, of the concept of sustainability and standards in the process can be systematized according to Figure 1.33.

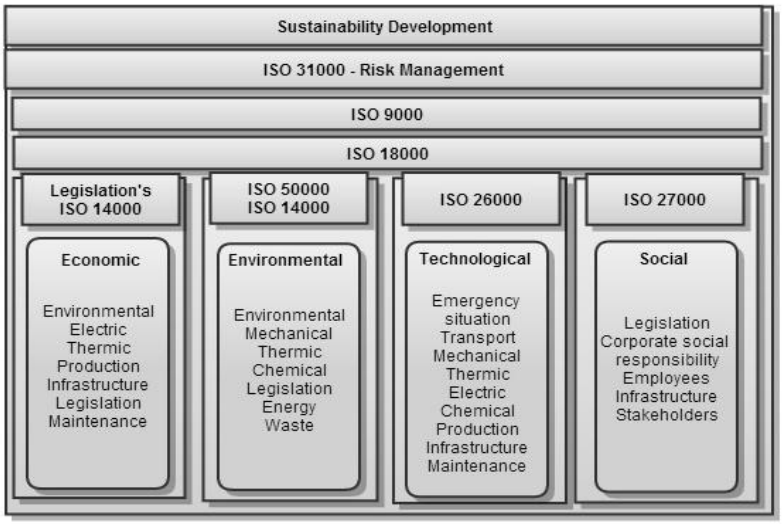


Figure 1.33. Conceptual model

In the proposal in Figure 1.33, it is observed that the risk assessment is performed depending on the subordinate issues of sustainability: economic, social and environmental. The technological subordinate of sustainability is addressed separately, because the author believes that a fair balance is not achieved without the real and complex support of technology, thus the technology becomes a complex problem. The whole approach is based on the requirements and directions provided by each family of standards relevant to risk assessment and sustainability: ISO 9000, ISO 14000, OHSAS 18000, ISO 26000, ISO 31000, ISO 50000. The entire implementation was made in a Web platform that has a dynamic form to be updated according to the company's activities.

Graphic Modeling –UML Diagram

The author presents the assessment process of the relation (risk management-sustainable development-relevant standards) by using sequence diagrams, Figure 1.34. Workflow system is developed using UML sequence diagrams. Sequence Diagrams can be used to describe internal processing as well as action-object flow.

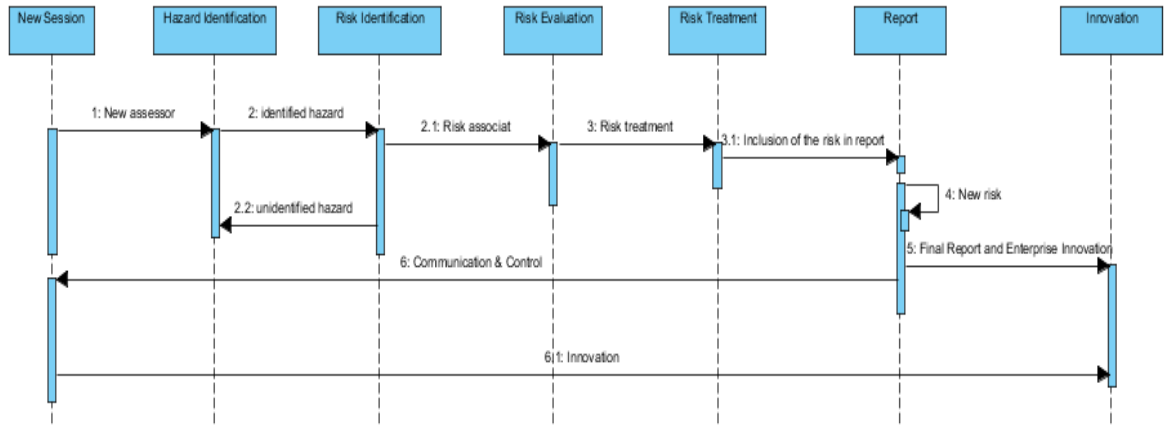


Figure 1.34. UML Sequence Activities

Sequence activity shows the evaluation process for one hazard (identified/unidentified) (from start to final report), see Figure 1.32. The logic evaluation process can be seen in this sequence. This sequence diagram model orders the messages with respect to time. Sequence diagrams presents interactions among classes in terms of an exchange of messages over time. They show a detailed flow for a specific use case or even just part of a specific use case (Mahmood, et al., 2012). These concepts are almost self-explanatory; they show the calls between the different objects (human capital, structural capital, and customer capital) in their sequence and can show, at a complex level, different calls to different objects.

The sequence activity presents the platform logic proposed for a hazard identified in the organization, as follows:

- Start a new working session from an existing account or create a new account
- Obtain general information about the evaluation procedure
- Tick the hazards in the implemented checklist. Hazards are organized into the four

subordinates: economic, social, environmental and technological. Each subordinate has a checklist for each contained area.

- If the hazard was identified, proceed to identify associated risk and impact assessment (I), consequences (C) and its frequency (F).
- If (I), (C), (F) have a low level (according to the implemented table of apparitions), this risk is isolated. If (I), (C), (F) have a medium or high level, we can start treatment.
- In the treatment step there are obtained preventive and control measures for the identified risk. This information is listed in the final report.
- After going through the subordinates of sustainability, we obtain the final report containing the measures and methods of prevention, control and communication that contribute to the enterprise innovation.

The full risk assessment process based on subordinates of sustainability and the requirements of relevant international standards of such activities contribute to enterprise innovation and the development of competitive advantage.

1.4.2. Risk and opportunity risk

Risk is an element in any process of an enterprise. While risks are dominating the business environment, opportunities are a concern for all managers. Defining features of this concept are positive connotation, negative connotation, opportunity, uncertainty and hazard. The management of the risks portfolio facing the enterprise is focused on risk management. Risk management provides an integrated picture for assessment, treatment, control, and monitoring risk. Positive connotation identified in the content of the risk contributes to the generation of opportunities for enterprise. Thus risk management becomes an intense concern because it contributes to the objectives of the enterprise, to increase competitive advantage and generate opportunities. One can say that risk management includes: hazard management, control management and opportunity management. Real assessment of the opportunities arising from risk management becomes an essential element in the process of risk management.

Risk is an inherent component occurring in enterprise at all levels of activities, which is based on a complex of factors. Due to the significant potential impact of these risk factors on the results of the enterprise and the impossibility of their full control by the enterprise, risk analysis is an important dimension of the strategic management of the enterprise which involves the following sequence of steps: risk identification, risk analysis and assessment, determine interventions priority to limit risk and risk treatment (Hopkin, 2012; Adair, 2013). Risk is a situation which occurs in the enterprise that can negatively or positively affect business objectives, including probability and opportunity being determined by a hazard. Real risk management contributes to the development of the enterprise.

Risk management: planning the future of the enterprise

Planning, identification, assessment, treatment, monitoring and controlling risk materializes in the risk management process (Mathrani, and Mathrani, 2013). As the risk involves five defining features (positive connotation, negative connotation, opportunity, uncertainty and hazard), by default risk management includes the management of these defining features. So the cyclic process of risk management involves cyclical concepts: hazard management, control

management and opportunity management. This cyclic process of interconnection is shown in Figure 1.35.

Figure 1.35. Risk Management: Hazard Management, Control Management and Opportunity Management

- Hazard Management - are risks that inhibit / jeopardizing enterprise objectives. An incorrect treatment or their isolation negatively affects the enterprise and the achievement of its objectives.
- Control Management - manage the uncertainty that affects the outcome of the risk. The risk has at least two results. One known (positive connotation / negative connotation) and one unknown affected by uncertainty. This uncertainty, also, can positively or negatively affect the enterprise [4].
- Opportunity Management - are those risks "searched" by the enterprise through risk management. Opportunity Management occurs because the organization is looking for new opportunities / possibilities for achieving objectives generate new ways of development and revenue growth.

Risk management process is based, as any management system the four-steps (PDCA: Plan, Do, Check, Act; and then modified in PDSA: Plan, Do, Study, Act), that is continuously repeated until the risks have an acceptable level: planning, risk identification, risk assessment, mitigation and tracking (Wu et al., 2013). After evaluating risks and opportunities within an enterprise, the answers to each of these must be defined in terms useful to contribute to the objectives and enterprise development. Further the author presents the implications of the responses to risk and opportunity as key elements in the development of the enterprise and maximize competitive advantage.

Keys to Successful Risk Management and Opportunity Risk Management

Often, where there is risk there is also opportunity. The risks associated with any opportunity should be assessed to determine if the opportunity really is favorable. There are a number of relationships between risks identified in an enterprise and the opportunities generated. The higher the risk, the less impact of the opportunity in the enterprise, results in an inverse proportionality. Another important relationship between risk and opportunity results from the maturity of the processes. Mature processes present fewer risks and more opportunities to a program.

Success in the enterprise risk management approach depends on the correct and actual identification of responses to risk and opportunity. Systematization of responses to risk and opportunity (Bekefi et al., 2008; Izvercian et al., 2012; Edwards, and Bowen, 2013), are shown in Table 1.33.

Table 1.33. Keys to Successful Risk Management and Opportunity Management

Risk Response	Opportunity Response
Avoid: change in the approach to the problem and takes into account the avoidance.	Capture: align work activities with the source and include opportunities in the deliverables.
Transfer: risk insurance or transferring them to third parties.	Transfer: entrusting the team that has the opportunity and including the opportunity into results.
Assume: Accepting risk is a passive strategy that allows any result to occur without interfering with the deployment cycle and the emergence	Ignore: opportunity with no further positive action and does not involve any change in the enterprise.
Mitigate: consists of actions to take place and reduce the likelihood or impact on the enterprise.	Pursue: opportunity with increase of the occurrence probability.
Sharing: connotations sharing with third parties	Maximize: added value by maximizing resources.

Thus, through a real and correct answer the risks and opportunities can contribute to enterprise development and implementation of the most real and fair rules of prevention and protection.

Risk management is a process to help enterprises to reduce risks in achieving enterprise goals. Both successful risk management and opportunity management add value to a enterprise. An opportunity management process is similar to the risk management process (Bekefi et al., 2008).

Effective management of risk and opportunities is increasingly seen as a competitive differentiator element, helping businesses to achieve success even if the economic environment is difficult. Managing the opportunity management involves creating a fertile climate for innovation. Opportunity Risk Management is a process in which the benefits are tangible. The key is to ensure that risk management is not done in isolation, but is included in every process within the enterprise. Some of the benefits (Bekefi et al., 2008; Dash et al., 2013) of this concept:

- Effective and focused management of enterprise resources
- A methodology for the whole team
- Increased credibility of the customer and effectiveness of business processes
- Optimization of production processes and development of an efficient development plan
- Identifying potential events that can be used to maximize business objectives.

Integrated Instrument for Risk and Opportunity Risk Management

This part proposes an integrated model to assess the risk and generate opportunities within the enterprise, Figure 1.36. This system can be developed using databases such as some of the contents of these databases can be made public through forums, thus developing possible involvement of partners in the enterprise development. Through these integrated concepts the information system proves two other benefits: advertising and communication (mutual help of the enterprises).

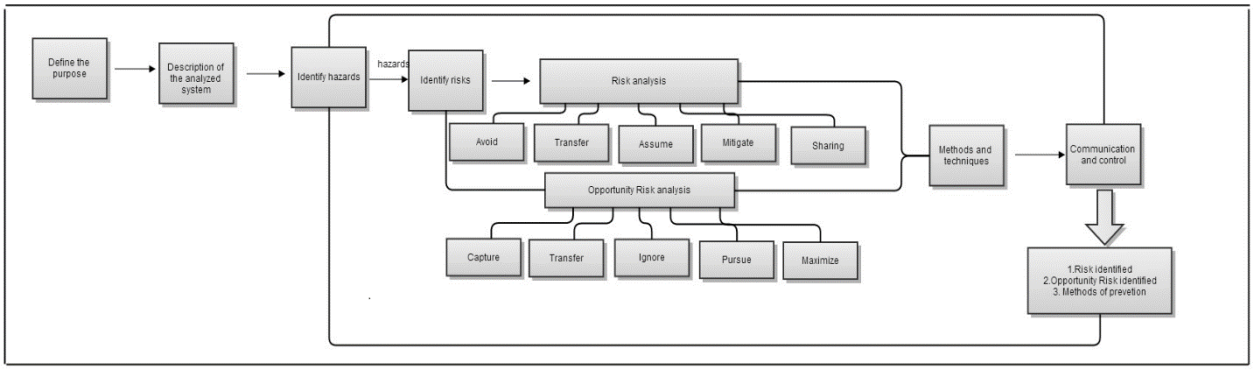


Figure 1.36. Model for Risk and Opportunity Risk Management

The first stage developed in this tool is the planning. Planning includes scheduling resources involved in the evaluation process, associated duration, budget and other preliminary items that may be determined by a brainstorming within the enterprise. The next step in the sequence for the proposed logic, is the process of identifying sources of danger that contribute to the emergence of risks in the enterprise. As a logical course, risks involve opportunity, and so the systematization of opportunities arising from the risks identified. The next step is the risk and the opportunity response planning. Planning and controlling activities involve minimizing risk and maximizing opportunities. Communication includes various opportunities like employee involvement in proposals for sources of danger, but also activities for sustainable development. Communication includes the final report, preventive measures, associated diseases and the influence of process evaluator attitudes.

Conclusions

Risk assessment is an important step in achieving the objectives of companies. All element of the risk management cycle are important, but the risk assessment is the headstone for all other elements.

The risk involves the five defining traits, presented by the author (positive connotation, negative connotation, opportunity, uncertainty and hazard), that identifies a number of opportunities for which the enterprise must respond real and fully, to implement them in the owned activities and processes. Thus, we discuss the opportunity risk process by which we define the enterprise model and responses.

Risk management becomes an integral element in the enterprise processes because by nature it helps to achieve the objectives. Managing the opportunity management involves creating a fertile climate for innovation. Opportunity Risk Management is a process in which the benefits are tangible. The key is to ensure that risk management is not done in isolation, but is included in every process within the enterprise. The proposed model is a starting step in terms of enterprise risk management.

Opportunity Management helps eliminate poor ideas before they consume substantial resources and allows at the same time the development of powerful ideas that support the continued development of the enterprise. Integrated components (Rausand, 2011; Borek et al., 2014) in this concept can be summarized as follows: generating ideas, recognizing opportunities, driving opportunities and implementing new ideas.

1.4.3. IT technology implications analysis on the occupational risk: cloud computing architecture

The section is divided into three major areas: the analysis of occupational risk implications at national and international level, the European priorities in terms of occupational risk and the existing cloud computing services. Since human resource is present within each organization, it is required a comprehensive and actual assessment of the processes in which they participate. Like in any daily activity, processes and people contribute to the emergence of risks. If each organization creates healthy and safe workplaces that means that it contributes to the sustainable development of the area in which it operates. It can be said that occupational risk assessment and occupational health and safety is the foundation for optimal functioning of the enterprise, thus aiding in reaching the enterprise objectives. The combination of these key concepts, occupational risk and occupational health and safety with technological developments contribute to an innovative approach to risk. This part presents the literature review, European strategic directions and their implementation in occupational risk assessment in Romanian organizations, analysis of work accidents in Romania compared to EU and author addressing occupational risk assessment using cloud computing by developing the associated architecture.

Human resource is an essential entity to any organization, so the occupational risk assessment is imminent. The human factor is the primary cause for most work accidents. The approach policy to occupational risk assessment must meet the criteria laid down in Law no. 319/2006, which introduces measures to encourage improvements in the health and safety of workers at the workplace. Occupational risk assessment is a tool that demonstrates the principles of prevention in the organization/unit. This means that each organization must anticipate hazards that can cause accidents at work or occupational disease, instead of reacting after such events have occurred in the workplace (Newman et al., 2012). An essential step to implement a responsible approach to health and safety at work is the evaluation of occupational risks. The safety and health is one of the key items in the general management (Sousa et al., 2014)

National statistics regarding working accidents, occupational diseases and absence from production due to occupational causes and accidents are not a reflection of reality and that is why the economic and social effects of those elements are hard to evaluate and stand as a base for coherent national strategies (Pece et al., 1998) At international level, there are a lot of available references, guides, specifications, national and international models aiming to the management of occupational health and safety that had evolved in different proportions from country to country (Ivascu, and Cioca, 2014). In Romania the only method to solve this problem: health and safety at work, is the one of the National Institute for Research and Development (Ivascu, and Cioca, 2014). This is a time and resource consuming method because there is not developed software, only rules and checklists to be completed manually (without using the computer).

Literature review

Occupational risk assessment is the process of evaluating risks to workers' safety and health from workplace (Friend, and Kohn, 2010). This process is a systematic examination of the elements of work that considers: what could cause injury or harm, whether the hazards could be eliminated and, if not, and what preventive or protective measures are, or should be, in place to control the risks. Occupational risk assessment is a structured process that leads to the generation of a report/plan that is made available for inspection and control bodies (Draghici et al., 2011).

We firstly need to look at the terminology used in job expertise, in order to go further on our research. According to Law on health and safety no. 319/2006 (published in Official Gazette/Monitorul Oficial no. 646/26.07.06):

- Professional work: activity done in state or private organizations based on contractual relationship between employer and employee (Draghici et al., 2011),
- Occupational Risk : risk developed in the workplace, in the process of work as a result of the hazard sources (Adler et al., 2008),
- Management of health and safety at work: a set of interconnected components of decisional, organizational, informational, motivational character, within the organization, through which it is implemented the management processes and relationships of OSHA , in order to get and maintain the required level of health and safety at work (Sa et al., 2014),
- Working conditions: all of the conditions in which the work process takes place: technical (technical processes used and the characteristics of the means of production), organizational (all measures applied to the organization of work and production) and environmental (all the physical and social environment characteristics in which the production takes place) (Reed et al., 2013; Burke et al., 2011).
- The workplace (system human – work tasks - production means – work environment): Assembly consisting of one or more performers and production means that interact based on an informational circuit under certain conditions of the work environment for succeeding in reaching the proposed objectives (Ostrom, and Wilhesem, 2012; Thorntona et al., 2013)

Occupational Security and Health Agency documents generate a complex knowledge base for scientific research on health and safety by promoting: best practices, statistics, publications, legislation, tendencies regarding research activity through the working groups formed at international, European, and national levels (Draghici et al., 2011).

Priorities for occupational risk in Europe for the years 2014-2020

EU priorities regarding occupational risks are formulated in OSHA report (European Agency for Safety and Health at Work, 2011) of January 2014. The report's objective was to identify priorities for OSH (occupational health and safety) research in the coming years in accordance with the Europe 2020 strategy and the Horizon 2020direction and their priorities and key objectives of 'smart, sustainable and inclusive growth' and 'excellent science -

competitive industries - better society. Occupational risk strategic directions proposed at European level are summarized in Table 1.34.

Table 1.34. Overview of research priorities (after European Agency for Safety and Health at Work, 2011)

Proposed direction	Actions
The economic dimension of occupational health and safety	Develop further the methodologies for estimating the socioeconomic costs of occupational diseases, work-related stress and violence at work.
	Strengthen research on the economic dimension.
	Decision-making at the company level under OSH.
Occupational health and safety communication and risk communication	Identify and characterize stakeholder and target groups.
	Evaluate the communication channels and media.
	Investigate the possibilities to use the new technologies.
	Develop risk communication.
Intervention research	Evaluate the OSH interventions at all levels.
	Develop comprehensive intervention models and strategies.
Demographic change — sustainable work for healthier and longer working lives	Evaluate the association of work, health, work ability and work motivation with work participation.
	The age of the employees.
	Health inequalities and work.
Globalisation and the changing world of work	Major health problems.
	Health management in restructuring.
	Changing organizations, new employment and work patterns, and psychosocial risks.
	Violence and harassment at work.
	OSH in small enterprises.
Occupational health and safety research for safe new technologies.	Risks in green technologies.
	Information and communication technology: opportunities and risks in the working environment.
	Electromagnetic Risk.
	Unknown risks of technology.
New or increasing occupational exposure to chemical and	Chemical Risk and Biological Risk. Management Risk.
biological agents	Mixed exposures in complex workplace settings.

Based on EU priorities (European Agency for Safety and Health at Work, 2014) regarding occupational risk, the author sets the foundation and treat (by exemplifying how they treat the proposed direction) the following strategic directions:

- The economic dimension of occupational health and safety: development of an assessment system that requires low cost and the maintenance is affordable.
- Occupational health and safety communication and risk communication: the use of modern technologies that allow communication at all levels of the organization.
- Intervention research: risk assessment at all levels of the organization.
- Occupational health and safety research for safe new technologies: identification of risks in new equipment and technology used in the organization and the dynamics of the proposed evaluation system.

Note that the authors treat all EU priorities in terms of technology and the dynamics imposed in the period 2014-2020, concluding therefore that the work presents a multidisciplinary sciences interconnection by integrating IT, management and health and safety.

Analysis of occupational accidents in Romania

Based on European priorities regarding occupational risk in the period 2014-2020, the author proposes the architecture of occupational risk assessment using Cloud Computing. Initial to the presentation of the technological solution for occupational risk assessment, the author presents the case of accidents at work in Romania in the period 2010-2013 to complete the action field and the weaknesses which need to be strengthened by the developed proposal. This statistic is presented based on the Labour Inspection in Romania, all the data has real and complex character based on Romanian organizations. For the data on the evolution of labor accidents in Romania, the author conducted the study on three main directions:

- Industry: dividing the 99 identified activities in the work environment in 11 sectors,
- Use of index frequency as extremely important information (showing scale status of the consequences of occupational risk),
- 2010-2013 analysis period, recent and relevant in developing an emerging tool in occupational risk assessment.

In the analysis of work accidents the following indicators are taken into account (Jackson et al., 2012; Lutchman et al., 2012; European Agency for Safety and Health at Work, 2014):

- Frequency rate: number of accidents per 1,000 workers,
- Severity rate: the total number of work incapacity days per 1,000 employees,
- Average rate: the number of days lost, on average, by an injured worker.

At European level, every year, over 5,580 people lose their lives after the occurrence of work accidents, and another 159,000 die of occupational diseases. In 2013, in Romania it was recorded a number of 3,627 injured people, including 199 fatalities (314 in 2012). In the same period there were 24 collective labor accidents in which 115 people were involved, of which 10 have died (Labour Inspection of Romania, 2014). Evolution of work injuries in the period 2010-2013 is systematized presented in Table 1.35.

Table 1.35. Frequency rate, Severity rate, Average rate and Work injuries - evolution, 2010-2013

Year	Work injuries	Frequency rate	Severity rate	Average rate
2010	3678	0.79%	41.3%	63
2011	4029	0.86%	43.2%	65.5
2012	4187	0.88%	45.1%	66.4
2013	3627	0.76%	41.8%	64.4

Analyzing Table 1.35, it is observed that there is a downward trend in terms of frequency rates, severity rates and average rates, leading to an evolution of the occupational risk assessment in

Romanian organizations. Heading towards European priorities it is quantified the need for integrative approaches to follow the four proposed directions, the system innovation and the reduction of work accidents. In an analysis of work accidents evolution curves are observed for different sectors, so it requires a detailed and comprehensive analysis of occupational risks of the 11 sectors defined by the author (Labour Inspection of Romania, 2014). Evolution of injured persons and fatalities for 2010-2013, in Romania, is presented in Figure 1.37, Figure 1.38, Figure 1.39:

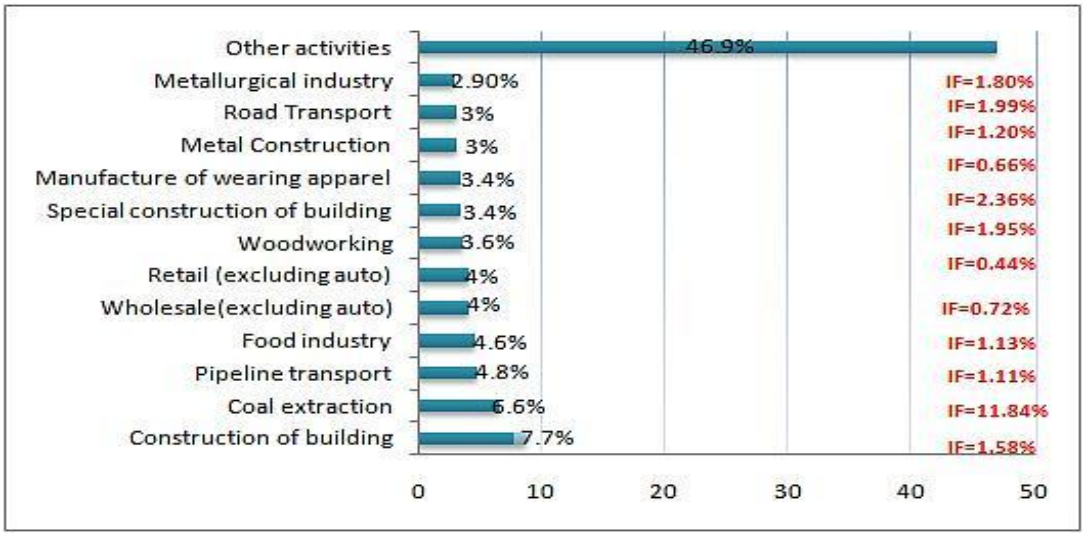


Figure 1.37. Number of work injuries 2010

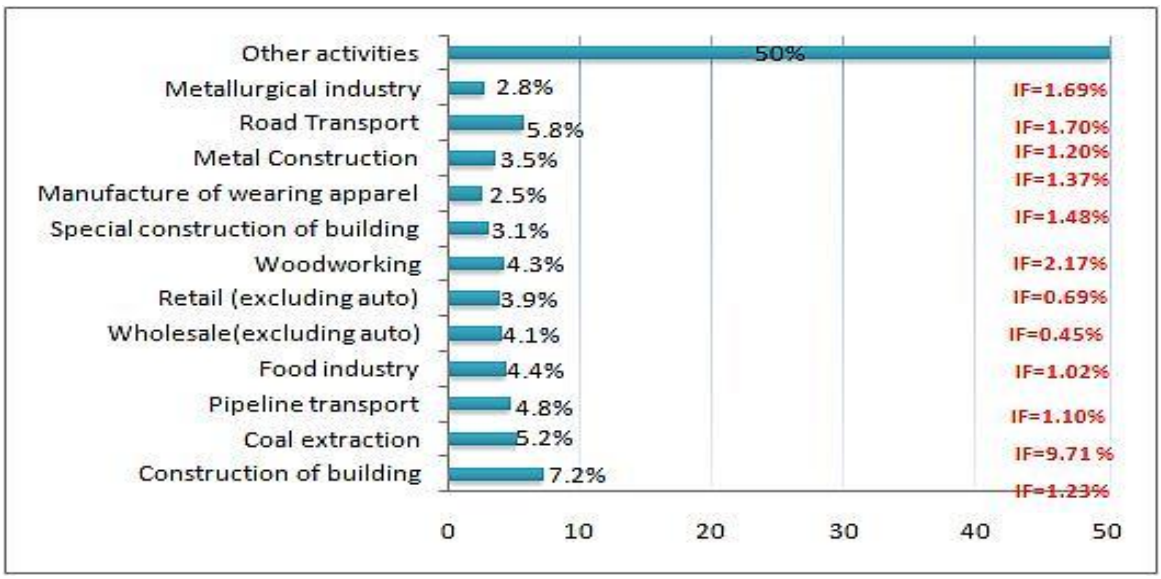


Figure 1.38. Number of work injuries 2011

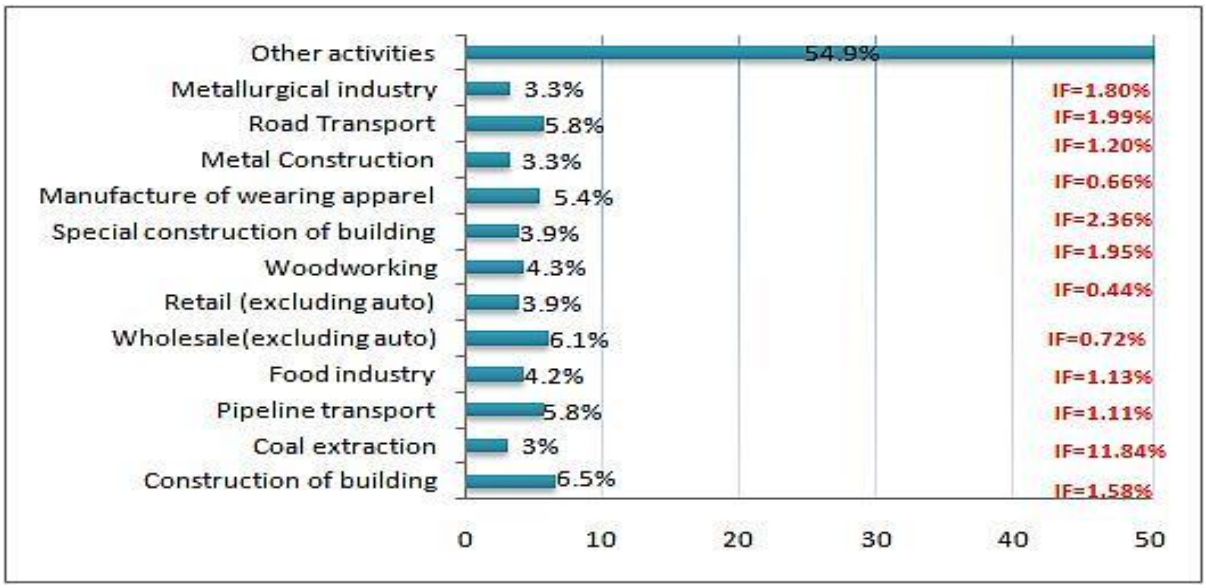


Figure 1.39. Number of work injuries – 2013

Source: Labour Inspection of Romania, 2014

According to studies carried out by the labor inspectorate in Romania, accidents analysis revealed that people aged 40-50 years have the highest share of 32.4% of all injured. Analysis of accidents in terms of seniority at work reveals that 63.3% of the total 2,295 injured people are workers with up to 5 years work experience (of which 30.8% or 1119 injured people are workers with 1-3 years work experience), and those from the work experience groups 5-10 years and 10-20 years are 19.2% and 10.1% of all injured.

Analyzing the implications of occupational risks described above, the proposed structure of occupational risk is systematized in Figure 1.40, being the base of the cloud computing architecture proposed. The proposed approach for occupational risk ontology design consists of the following stages: capitalizing knowledge and systematizing the European priorities in the field of occupational risk, the situation of accidents at work in the period 2010-2013, the law on occupational risk and the 11 areas of occupational risk identified in the Romanian work environment. Based on these preliminary stages it will be showed the occupational risk assessment approach using cloud computing architecture.

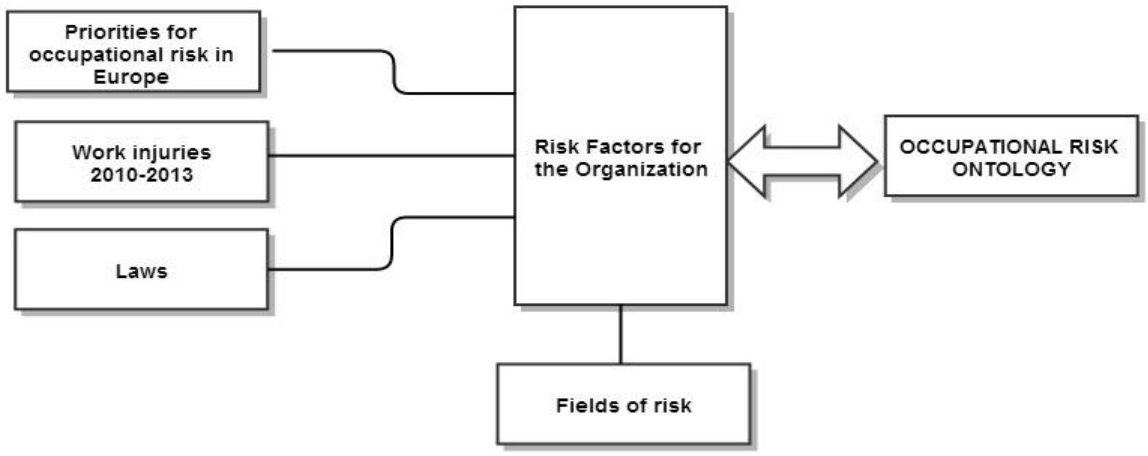


Figure 1.40. Proposed approach for the occupational risk structure

New technologies in addressing occupational risk

There are efforts to make the transition from traditional solutions for occupational risk assessment and e-health services to Cloud approaches. Until now there have been developed a number of approaches to this concept, so we can say that this opportunity is now increasingly addressed. The new system for access to information technology (IT) - Cloud Computing - significantly reduces costs, IT complexity and scope while increasing the real optimization for work-loads and delivery services. Cloud computing allows a very high degree of scalability, offering superior user experience and is based on the new Internet-based evaluation principles (Izvercian et al., 2013)

What is cloud computing?

Cloud Computing is a set of hardware and software resources that can be accessed on demand on the Internet, in the form of a service (Maingi, 2014). Cloud computing includes 3 three fundamental models: Infrastructure as a service (IaaS), platform as a service (PaaS), and software as a service (SaaS) (Mu-Hsing Kuo, 2011).

- Software as a service (SaaS): The applications are hosted by a cloud service provider and made available to customers over a network, typically the Internet.
- Platform as a service (PaaS): The development tools are hosted in the cloud and accessed through a browser. The developers can build applications installing any tools on computer.
- Infrastructure as a service (IaaS): The cloud user outsources the equipment used to support operations, including storage, hardware, servers, and networking components.

There are different approaches of the three services offered by cloud computing depending on the country and on the subject. Organizations around the world are deploying cloud computing for critical applications and other uses. The differences in adoption rate are far greater between countries than between industry groups (Harris, and Alter, 2010). Through a systematization of the works in the literature (Brender, and Markov, 2013), the author concentrate these implications in the charts below, on fields and countries, Figure 1.41.

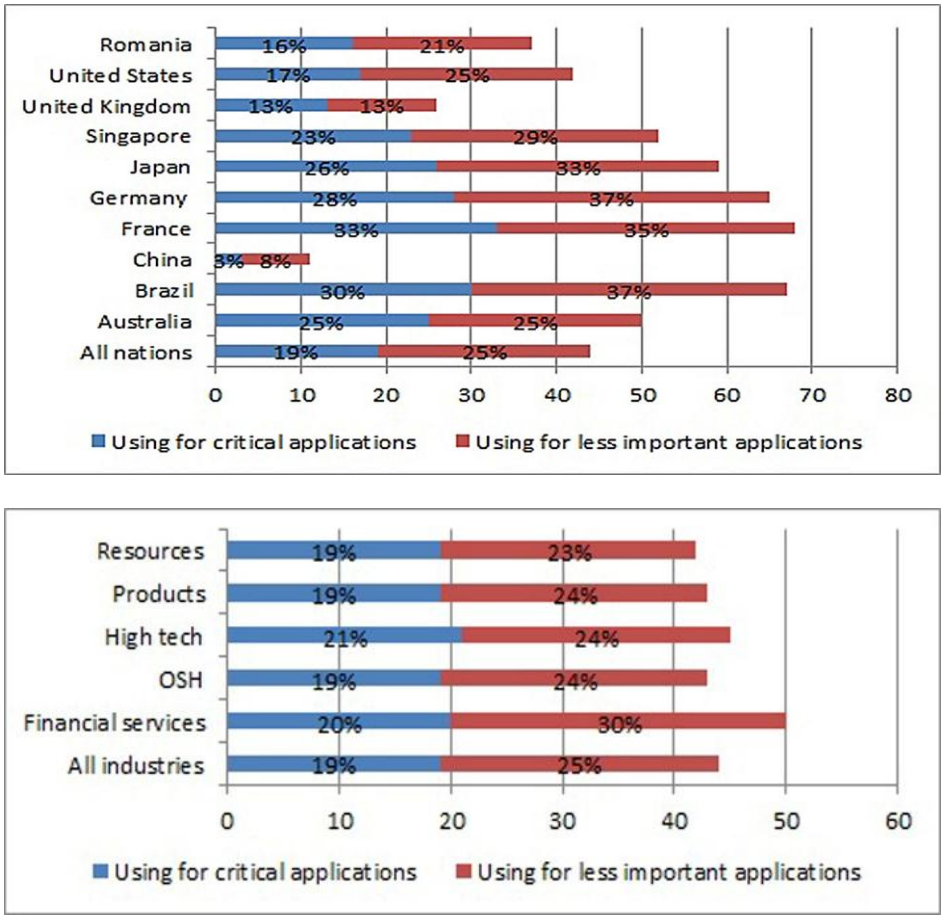


Figure 1.41. Average of private cloud platforms and software, infrastructure, process and platform services.

It can be noted the active involvement of Brazil and Germany in using cloud computing, being innovative and using emerging approaches. Regarding areas (fields), cloud computing is used mainly in high tech and financial services, differences between areas being small. In an analysis (Rolim et al., 2013) of the types of services using cloud computing, Figure 1.42, it is apparent the inclination towards SaaS solutions.

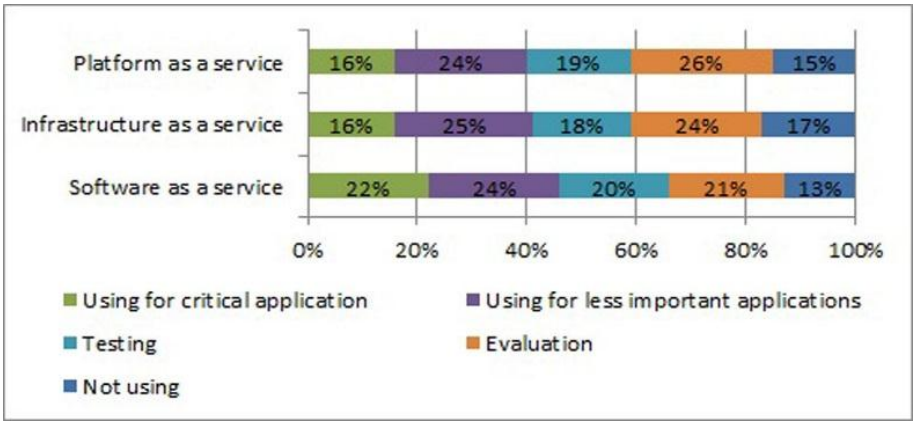


Figure 1.42. Usage of Cloud Computing (SaaS, IaaS, PaaS)

Drivers of cloud computing structure

Because the opportunities offered by cloud computing begin to be exploited by more and more organizations, it is required a systematization of the drivers of cloud computing to exemplify the importance of using this concept in e-health. The main drivers are summarized in the Accenture Institute for High Performance report (Fan et al., 2010), Figure 1.43.

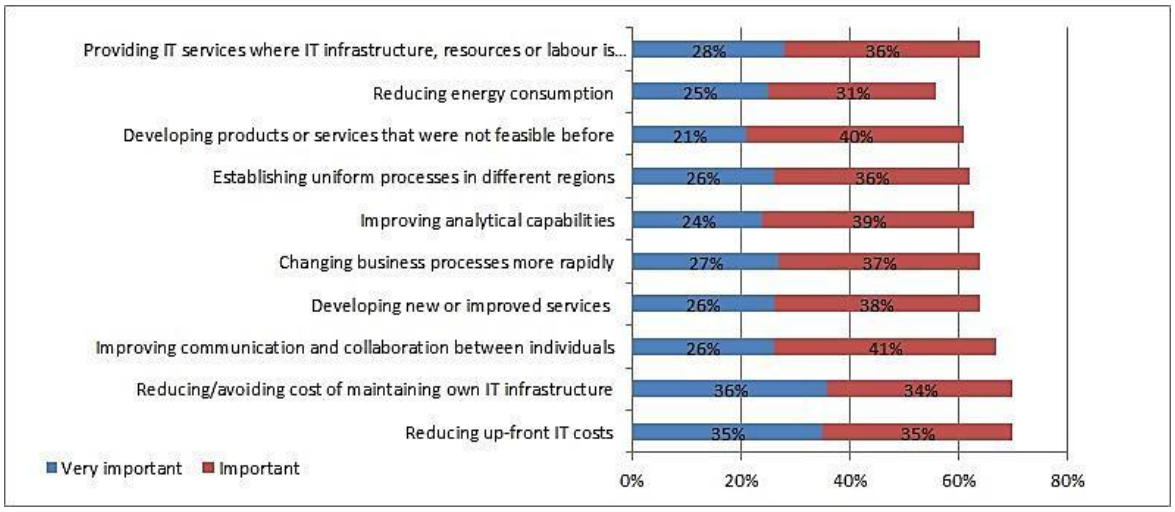


Figure 1.43. Key Drivers of cloud computing

Among the key drivers there are: reducing cost, adaptability, energy reduction, uniformity of solutions and concurrent use of different solutions. Thus, so many advantages of using these services being highlighted we should approach cloud computing in e-health, specifically in occupational risk assessment.

Cloud Computing and Occupational Risks

A prerequisite of currently developed solutions is that they are delivered SaaS (Software as a Service). The benefits of such a request are numerous, so that organizations realize the advantage of implementing such a solution.

The benefits of SaaS delivered solutions fit the following:

- Reduced costs and reasonable effort for staff so that operational activity is not affected during implementation
- Zero initial investment and competitive TCO (Total Cost of Ownership) by contracting a SaaS solution with periodic payment services.
- Costs predictability through periodic payment services.
- Simplifying the IT environment through hosting the risk assessment solution in a professional data centre.

In the e-health there are a number of approaches to occupational risk assessment using cloud computing. Among them were Rolim and et, DACAR solution and CARE solution. Rolim et al proposed a cloud-based system to automate the process of collecting patients' vital data via a network of sensors connected to legacy medical devices, and to deliver the data to a medical center's "cloud" for storage, processing, and distribution. The main benefits of the system are that it provides users with 7-days-a-week, real-time data collecting, eliminates manual collection work and the possibility of typing errors, and eases the deployment process (Baru et al., 2012). DACAR aims to develop, implement, validate and disseminate a novel, secure, "in-the-cloud" service platform for capture, storage and consumption of data within a health care domain. The objectives of the project include: development of novel distributed and secure infrastructures based on role and inter-domain security polices; smart device and system integration platform based on novel digital forensic security technology; generic risk assessment strategy for smart device and system integration; clinical evaluation, dissemination and commercialization (Sosinsky, 2011). CARE, CyberHealth for Aggregation, Research, and Evaluation, was mainly proposed to enable data integration, filtering, and processing for data mining in e-health. They identified a need for an infrastructure for data integration and languages, algorithms, and tools to analyze medical information to discover new medical patterns. With this approach, heterogeneous data from different sources can be integrated, processed and analyzed to improve health understanding and medical treatment effectiveness (Cioca, and Moraru, 2012).

Analyzing the needs of the e-health environment, the author proposes occupational risk assessment solution in SaaS. The SaaS systems in the cloud will be replaced with local systems in the next years, thus, it will be easier to create new SaaS systems which is based on standard modular parts (Rodrigues et al., 2014). In order to assess the occupational risk the author has developed the diagram of Figure 1.40 which includes the basic steps of a management system: (1) define the purpose and description of the analyzed system, (2) identify hazards based on checklists in the areas defined by the author in the risk analysis (metallurgical industry, road transport, metal construction, manufacturing of wearing apparel, special construction, woodworking, retail, wholesale, food industry, pipeline transportation, building and construction cool extraction), (3) identifying the risks associated with sources of risk identified in the 11 fields, (4) assessing the severity, likelihood and consequences of identified risks, (5) treatment of identified risks, (6) communication and control, (7) preventive and control measures and (8) continuous monitoring (resumption). Risk assessment is performed through a qualitative assessment (European Agency for Safety and Health at Work, 2014) of factors: severity, probability and consequence. These qualifications are: low, medium, high. Allocated

coding for low is bit 0, while for medium and high coding is bit 1. If the product is 1 it is proceeded to treat and prevent future occurrences. Just for occupational risks with medium impacting on the workplace environment a space is allocated in the treatment plan. This treatment plan is communicated to all levels of the organization as a priority for achieving organization objectives and health and safety at work. This solution is developed using databases and HTML programming, using the services offered by cloud computing. The architecture for implementing the solution is found in Figure 1.44.

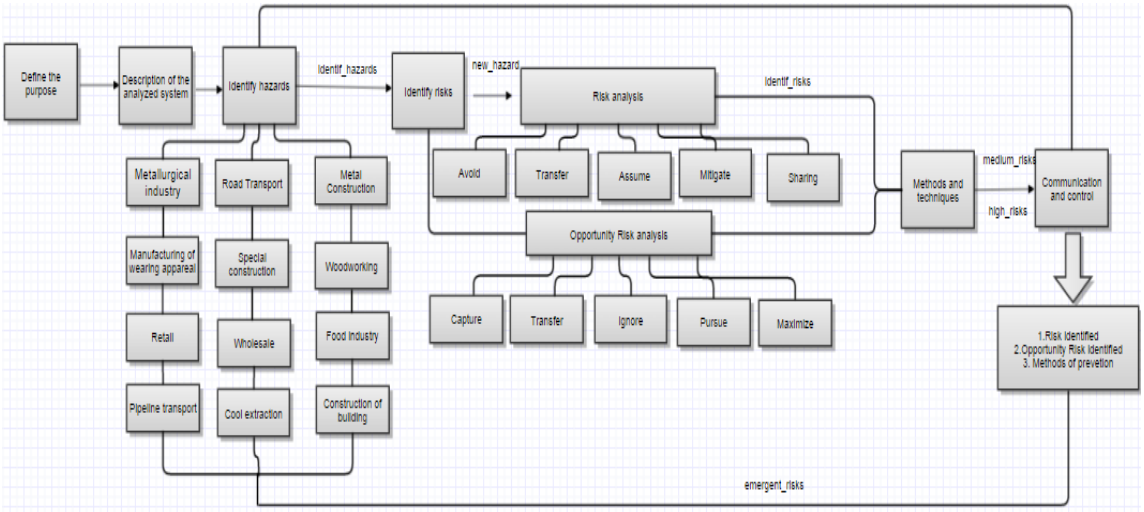


Figure 1.44. The concept model structure of the occupational risk assessment

To identify occupational hazards in the workplace it has been prepared a checklist which is included in PaaS. This list may be extended depending on the activity of the organization. Active involvement of all employees in the process of gathering information helps to correctly identify the hazards. Using the MySQL on a general hazard identification list it was created a knowledge base containing: award rules, rules for calculating the scores and probability assessment rules. After querying the knowledge base for a sector, you will see the result of the risk assessment, the assessment conclusion and methods of prevention, protection and proper treatment. At the bottom are Security Mechanisms, which are used to meet the authentication, data integrity and confidentiality requirements. Infrastructure as a Service includes the required base for developed application.

The applications are hosted by a cloud service provider and made available to customers over a network, typically the Internet, SaaS.

Cloud Computing - cloud services and storage - is accessible from anywhere in the world over an Internet connection and occupational risk assessment is easy to assess. The UML (Unified Modeling Language) deployment diagram is shown in Figure 1.45.

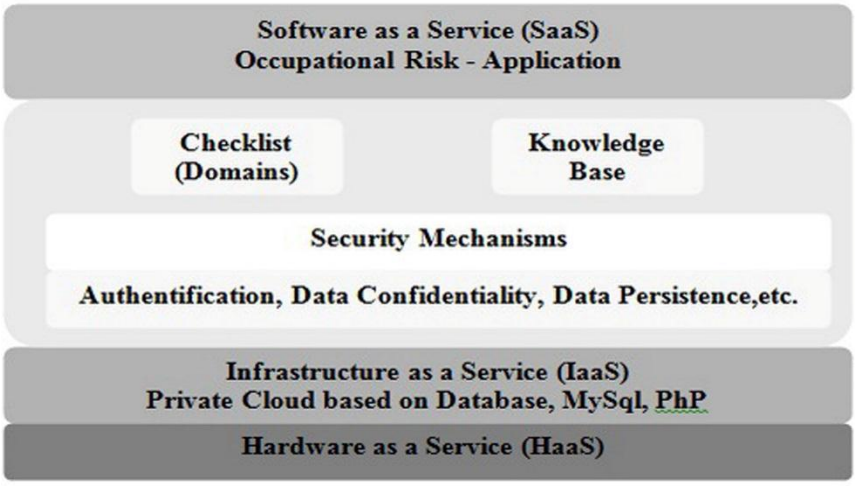


Figure 1.45. Conceptual architecture of the proposed platform

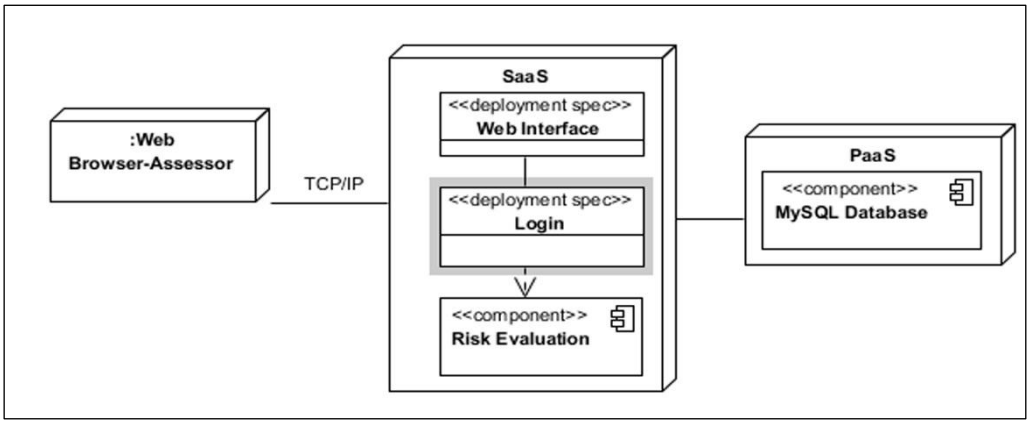


Figure 1.46. Deployment diagram for occupational risk assessment approach

The evaluation process is as follows: the evaluator accesses through a TCP / IP the risk assessment platform that is in cloud computing. At this point we get a login interface and then we can begin the evaluation process. When the evaluation process is started, the database of MySQL is called, which is in IaaS and the evaluator gets the checklists afferent to the risk assessments. The scheme of the evaluation process is shown in Figure 1.46.

Conclusions

Based on the literature the author has selected the defining concepts of occupational risk: hazard, risk, accident, consequence, severity and probability that have been integrated in the proposed solution. Following European strategic directions for the years 2014-2020 this solution correlates with the main proposals: the economic dimension of occupational health and safety, occupational health and safety communication and risk communication, intervention research and occupational health and safety research for safe new technologies (European Agency for Safety and Health at Work, 2014). The four selected directions contributed to the choice of technological support for software implementation and the developed analysis. Being defined the directions and terms that were used, it was pursued an analysis of work accidents in Romania to define the most important 11 fields in which we are sizing the hazards in organizations. To implement risk assessment there were selected the

services offered by cloud computing based on research conducted by the author. Following the presentation of data and analysis on the use of cloud computing it was considered mandatory to use this new and approachable concept. A literature review of health Cloud issues was presented in this section with emphasis on the importance of the concepts involved, implementations and challenges. Considering the risks and benefits of using Cloud Computing architecture, the author have proposed a strategy of adopting this approach in occupational safety and a risk assessment system. In future research we will test this possibility of risk assessment on various organizations.

1.4.4. OSH - sustainability connection: innovation, education, and benefits

The three responsibilities of the environment, society, and economy are used to model how sustainability can be incorporated into an organization's mission, goals, and practices. There are many worker problems embedded in the concept of sustainability. From the perspective of sustainable development, occupational health and safety (OSH) refers to promoting safety, security, health and welfare of workers. Using an integrated sustainability approach offers a way to rethink worker protection approaches and raises new exploration issues and innovation opportunities. The purpose of this part is to present the connections between OSH and sustainable development taking into account the needs of the economic environment. It focuses on Safety and Health's Core Role in Sustainability. Researchers have also tried to advance the road to sustainable development through innovation and improvement of occupational and health security.

Sustainability focuses on leadership, innovation, and goes beyond simplicity of compliance. It also provides a direct link with stakeholders and develops new partnerships. Establishing and applying standards is not enough to prevent millions of workplace injuries and diseases occurring each year. From this perspective, companies should take innovative measures to reduce the number of work-related accidents. The mission of organizations is to get secure jobs. In order to achieve this mission, innovative strategies tailored to current needs and aligned with international approaches are needed. Organizations spend annually billions on sustainability (Duijm et al., 2008; Nordlöf, et al., 2017)

Sustainable development focuses on measurements, reporting, standards and certifications, research, education or investment, but an essential part of sustainability efforts should be the safety and health of workers. Developing a safety culture at work has become a competitive factor for sustainable companies (Guiras et al., 2018). Protecting the safety and health of employees was a requirement set out in the Brundtland Commission report. The report was published in 1987. Organizations have to deal with the management of risks and dangers at work to protect the health and safety of their employees.

Employee engagement is one of the fundamental principles of a comprehensive health and safety program. This program helps identify the innovation opportunities for the employer. Employee involvement can improve not only safety and health, but also business performance and education. Employees have in-depth expertise to provide insight into the design and design of products and processes. These actions ultimately have the role of minimizing dangers and improving efficiency (Alli, 2008).

Thus, through an integrated approach to sustainable development and OSH, jobs are becoming safer, more innovative and more sustainable. In the literature, there is little empirical research on planning and control systems for sustainable businesses. Empirical research on the assessment and monitoring of safety and environmental performance is reduced in number in the literature (Alli, 2008).

The objective of this part is to identify the link between OSH and sustainable development taking into account innovation and education.

Occupational health and safety (OHS) imperatives

OHS promotes and maintains the highest physical, mental and social level for the well-being of workers in all organizational occupations. Occupational health issues are particularly important in countries such as Africa and Asia. Africa has insecure working conditions in sectors such as mining, construction, manufacturing and even services. Africa and Asia are described as having the most dangerous practices and conditions in managing child labour and employment. Migration, particularly from Africa to Europe, is one that indicates the existence of unsafe and unsustainable practices at work. Existing practices at EU level contribute to the safety and security of the workplace. There are stable rules and policies that monitor OSH and develop improvement strategies. The number of non-fatal accidents at work in the European Union is increasing compared to 2013. Figure 1.47 shows that in 2017 there is 10% more accidents than in 2013. This increase may be due to the development of industries where the number accidents are higher, education / training is inefficient and innovation at work is lacking (National Institute of Statistics, 2017).

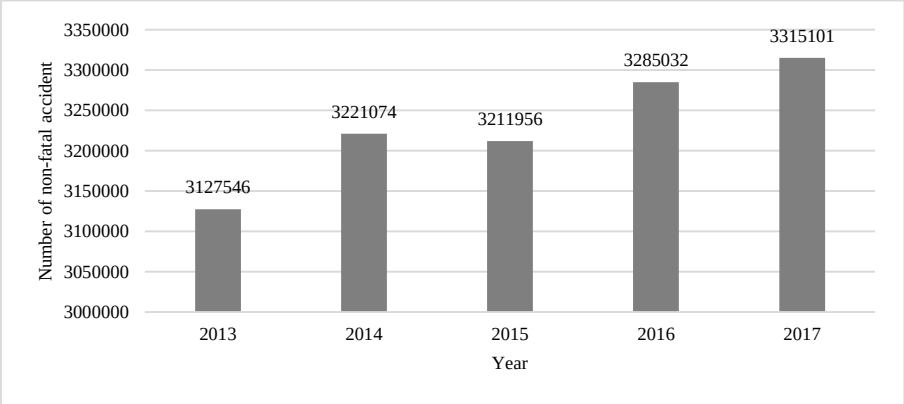


Figure 1.47. The situation of non-fatal accidents at the European Union level during the period 2013-2017

In Romania, Figure 1.48, the number of non-fatal accidents for the period 2013-2017 follows the situation at EU level. It can be noticed that the year 2017 is the most non-fatal accidents. In 2017, there is a 30% increase over 2013. Most accidents are recorded in the construction, transport and storage industry, manufacturing and agriculture.

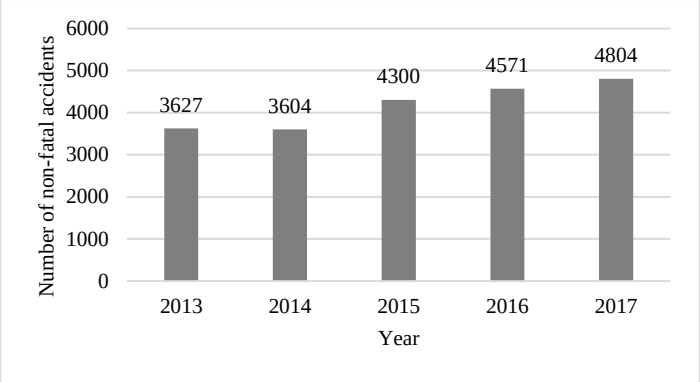


Figure 1.48. The situation of non-fatal work accidents in Romania during 2013-2017

The link between occupational safety and security and sustainability

Sustainability organizations' concerns have emerged over the past 20 years in response to globalization trends that affect businesses and their ability to provide value for stakeholders. This area of sustainable development is not a new one. It is rather an aggregation of practices, disciplines, education and reporting. Sustainability is undoubtedly of greater importance, as the challenges faced by businesses are evolving. These organizational challenges include workforce and social needs, increased competition for natural resources, increased concern for society over climate change, pollution and nutrition. Organizational concerns are intense for recycling, re-use, renewable energy production, and corporate social responsibility (Boini et al., 2017) For security experts, these organizational preoccupations are impressive. But, on the other hand, the security message and the Sustainable Development Goal (SDG) refers to the safety of society, and emphasizes less the need to create sustainable jobs. The goal is that if implemented correctly, organizations will create value for their shareholders and customers in an increasingly competitive and complex environment, but will also bring significant value to the communities in which they operate. But companies can only grow sustainably unless they have secure and healthy jobs. The first interference between OSH and susceptibility that can be perceived is that in Figure, the 3 P: people, planet, profit. These three entities are strongly integrated into OSH culture. When we talk about people, we talk about safety, health, development. In the same way, when we talk about the planet (environment), we talk about the sustainable economy and the environment. The environment is the place of life, and the working environment is comfortable for people. Finally, when talking about profit (economy), we are talking about the expected result and about a controlled environment (planet) that results in sustainable development. Thus, these three pillars contribute to improving OSH and sustainable development (Shamsudin et al., 2014).

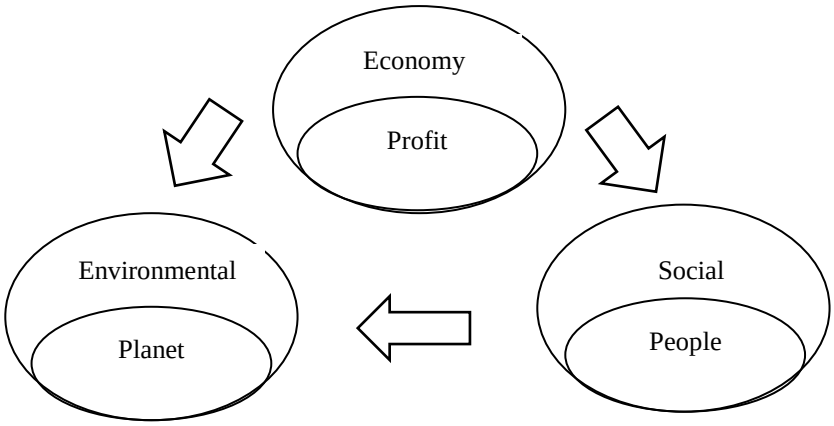


Figure 1.49. Important factors of sustainability: profit, planet, people

Figure 1.50 is a schematic representation of the relationship between OSH and sustainability. This figure highlights the fact that the triple bottom line of sustainability (economic, social and environmental) influences the quality of products and production processes. In turn, it is influenced by organizational culture. At the same time, the development of secure and sustainable jobs is influenced by employee education, the ability of the organization to become competitive and the implementation of sustainable development. Therefore, without the improvement or innovation of safety and health at work, occupational accidents, diseases and costs will not be reduced.

Without taking into account the importance of efficient use of an organization's resources, challenges to health and safety at work cannot end. If the organization fails to control these issues, the result of the profit and the impact on the business environment will not be at the level of the expectations of the stakeholders. Improving OSH contributes to improving production capacity and product quality (Shamsudin et al., 2014). Sustainable development contributes to the efficient use of resources in production processes. Therefore, sustainable development is an integration of the 3Ps, which are found in the three sustainability responsibilities: economic, social and environmental.

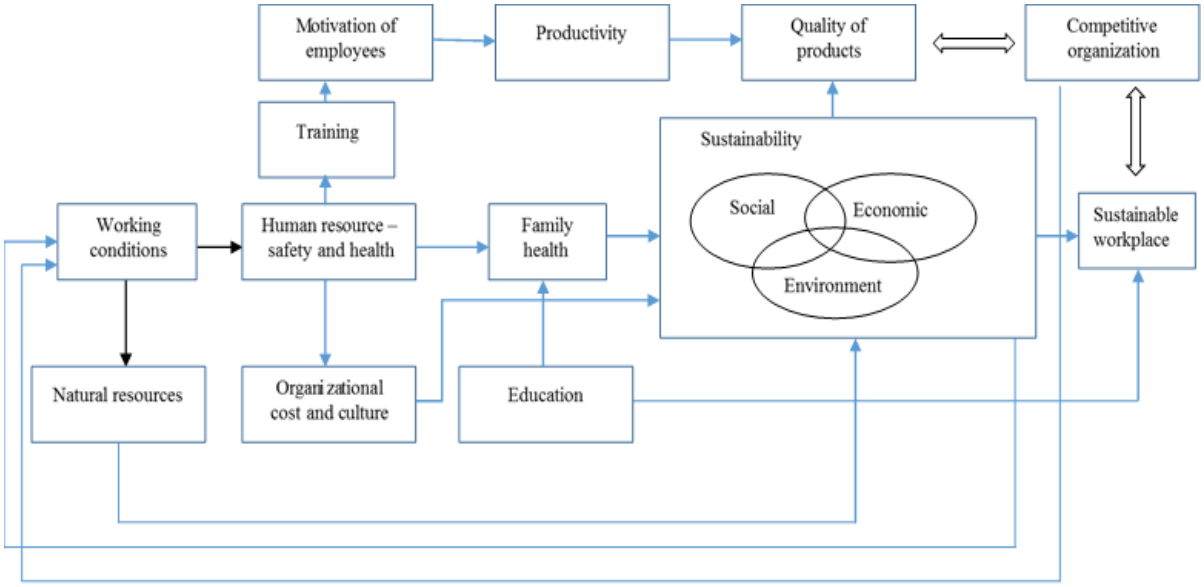


Figure 1.50. A model of the link between sustainability and OSH

The integrated approach to OSH and sustainable development contribute to creating safe and sustainable jobs. The two concepts cannot be treated separately. A company cannot grow sustainably if the OSH practices are deficient. On the contrary, a company that has sustainable practices in terms of OSH can become a competitive and sustainable company.

Workplace and innovation: benefits and education

Safe jobs and healthy employees are the premises for sustainable jobs. The pillars that underpin the development of sustainable (Shamsudin et al., 2014; Boini et al., 2017). jobs can be systematized into 6 factors, as follows:

- **Improving working condition –** is an important step given that the employee is a key element for the organization. If the employee has efficient working conditions, productivity can increase. Efficiency of the economy and improvement of social standards must become a priority for most organizations.
- **Workplace innovation and technology** – technology is one of the most effective ways to improve working conditions and achieve competitive results.
- **Education** – Employee education contributes to the understanding and learning of organizational best practices. Continuous employee training can help reduce work-related accidents. Training courses for employees are directly linked to the creation of sustainable jobs.
- **Organizational culture** - culture is dynamic, it varies from society to society and requires an analysis of social culture when it comes to improving the working environment. Social culture contributes to the development of organizational culture through its actions for people.
- **Improving strategic decisions** – stakeholders should take the best strategic decisions for the organization, based on employee health and safety.

- **Workplace control** – control of workplaces through appropriate techniques and methodologies contributes to reducing occupational risks and increasing job security.

The benefits of developing healthy jobs are outlined in Table 1.36, divided by the three sustainability (economic, social and environmental) responsibilities. At the same time, the benefits are presented on two important components: innovation and education**.**

Table 1.36. Benefits of the link between OSH and sustainability

Responsibility	Innovation	Education
Economic	Effective control Cost reduction Efficiency of supplier selection process Reducing losses	Engage trainers for using integrated programs Standardizing employee work Reducing employee negligence
Social	Improving stakeholder relations Improve public image Improving employee work Reducing overworking of employees	Increase communication level Improving communication techniques Increasing the number of candidates in the interview process
Environment	Reducing the negative impact on the environment Increase reuse The introduction of innovative concepts contributes to reducing the amount of gas generated	Employee involvement in corporate social responsibility actions Increasing health at work Reducing stress at work

Sustainable development cannot be taken into account separately, without taking into account workplace, safety and health improvement, reducing accidents and occupational diseases, workplace education, workplace innovation, safety and health, environmental control. The organization's financial results and sustainable development are interconnected parameters. Environment and society are considered key elements for increasing competitiveness (Shamsudin et al., 2014). A new organizational management style and innovative systems for improving safety and health at work are important pillars in organizational development. Increasing levels of education and employee interest contribute to reducing the negative impact on the environment and implicitly improving the quality of life. The long-term effects of culture, technology and politics are rooted in sustainable development in terms of safety and health at work.

1.4.5. Analysis of the causes of work accidents in Romania in the period 2011-2013

Occupational health and safety is very important for any organization in the context of sustainable development. The development of optimal working conditions contributes to the development of sustainable organizations that are aligned with European standards. This part presents an analysis of the causes of accidents at work in Romania divided into groups of causes. After analyzing these factors, a model of causes is presented that affect the seriousness and fatality of work accidents. Work accidents occur most often on the basis of budgetary difficulties of organizations. Given the current economic situation, organizations are trying to cut costs or invest small amounts in pre-venting accidents. Another problem reported in various studies (Probst et al, 2008; Lopez et al, 2011; Fuente et al., 2014) is that in different countries,

work accidents are not fully recorded. Most work accidents are recorded in the construction organization (Joao, 2012, Costa et al., 2012; Suarez-Cebador, 2014). Basically, the published results are relative and not actual reality. In this research is presented the relative reality of Romania based on data from the Labour Inspection in Romania.

The legal framework in Romania

According to the Law on health and safety no. 319/2006 (published in Official Gazette no. 646 /26.07.2006):

- Work accident represents "body injury and occupational acute poisoning that occur during the process of doing the work or service and which causes temporary inability to work for at least three days, disability or death";
- Event represents "the accident that led to death or injury to the body, produced during or in performing official duties, missing person or the case of accident of traffic or route, while involving people employed, dangerous incident and the case of likely occupational disease or work-related".

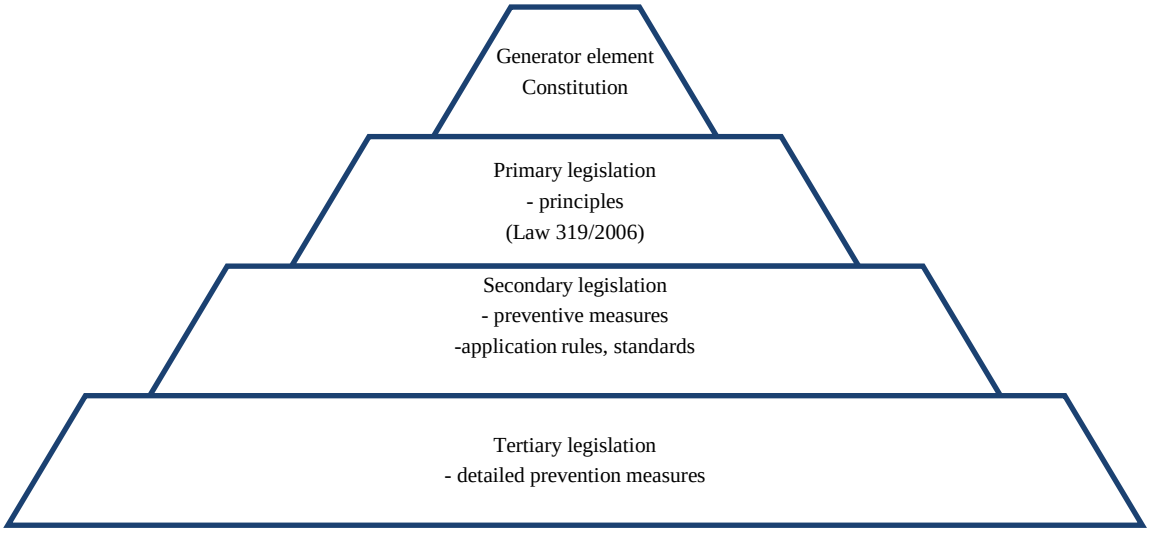


Figure 1.51. The structure of the legal system of Romania in the OHS (European Agency for OHS)

In Romania, the legal system in the OHS is established by the Constitution of Romania. Creating a controlled work environment involves improving knowledge on the causes of risk production by all actors. This means developing an approach both global and preventive focused on promoting sustainable jobs, beyond the mere prevention of specific risks. To develop a controlled environment there must be analyzed three mutually reinforcing components: education, awareness training and treatment of causes. Causes of accidents also show an uncertain component, since at any moment a new hazard of the job can be developed. Lago et al. 2012 reported that the human is easily adaptable to various environments. Therefore, by analyzing the history of the organization the present causes of work accidents can be analyzed. Their evaluation and presentation is made in the next section. The legislative, sometimes difficult, helps prevent accidents declaring and the implementation of accident

prevention models. Based on the legislative framework the causes of accidents nationwide are presented.

The OHS European directives

Professional risks assessment approach (that refers to the integrated process of analysis and evaluation) is linked with the general concerns of work systems safety assurances and organizations environment policies development and implementation. Nowadays, organization responsibility (related to economic, environment and social field) is an important subject and announce the next Responsibility Society that will follow the Knowledge Base Society. There have been recognized that workplace safety and health is a mandatory action that have to be taken into practice for the benefit of both workers (employees of all categories) and the business itself (for managers and different stakeholders). Managers of all levels, specialists and researches are concern of the problems related to the working systems impact on the environment and also, on life quality. They support actions or initiatives that aim to diminish or eliminate the work accidents and occupational diseases, by using different methodologies of analyzing different risk categories impact or influence in practice (risk sources, the way of development, evolution, impact, effects and measure of diminishing or elimination) (Thébaud-Mony et al., 2012). The following definitions could underline the importance of occupational risk assessment as part of the occupational safety and health management within an organization (European Agency for Safety and Health at Work, 2013): (1) work accident means "*the hurting of the human body and occupational acute intoxication that are happening during working process or during work duties that are causing the lost of work capacities at least for three days, invalidity or death*"; (2) occupational disease "*the disease produced by the exercitation of a profession, caused by physical, biological, chemical agents from the working environment and the overload of organs and systems during the working process*".

Started from this brief overview of the problem there should be mention that (badri et al., 2012) have proposed an integrated approach by considering specific "laws, the management systems view and OHS risk management throughout project life cycle and efforts" in order to couple OHS risk management to industrial safety practices including approaches using historical data and industrial interventions. This approach has been considered for our experimental researches, too.

The European survey of enterprises on new and emerging risks (ESENER) in 2013, has underlined importance of occupational health and safety information and knowledge. The survey results analysis (according to the European Framework Directive 89/391/EEC) aims to provide workers (in all Member States) with a common minimum level of protection from work related risks, but also it show the precise way in which these legislative provisions are translated into occupational safety and health management in the workplaces from one country to another, as well as by industry sector and organization size (ESENER, 2013). ESENER is developed within seven groups of countries (33 countries located in Europe) reflecting broadly similar contextual influences in terms of regulatory character and style, labor relations, social protection systems and other national regulatory, economic and social characteristics that are likely to be influential over the operation of regulatory requirements on workplace occupational safety and health (OSH) management.

The aim of the ESENER research was: (a) to provide a description and reasoned analysis of the most important factors affecting the way OSH is managed in the workplace (e.g. the environment); (b) to consider how this environment affects these three broad areas (e.g. the influence of the environment on workplace OSH practice). In order to achieve these aims a pragmatic and innovative mixed-methods approach was adopted involving desk research, secondary analysis of the ESENER data and new qualitative data collection. In addition, key expertise from each of the selected Member States was dynamically combined with broader expert views at both the European Union and wider international levels. ESENER results were structure in three main areas of interest, namely: occupational health and safety management, psychosocial risk management and the involvement of workers and their representatives (Erickson, 2003; ESENER, 2013). One of the main conclusion of this research was related to OSH management and most its five determinants that act different from a country to another (underline by the macroeconomic analysis of the OSH policies related to each country) (Takala, 2012). There have been underline the changes brought by globalization and its attendant labor market restructuring, budgetary deficits and decline in unionization, and that effect the development of diverse OSH management practices. In addition, different policies of regulatory bodies, social, economic and professional actors have rapid and profoundly influence the determinants of OSH management practices in all EU countries.

The European Agency for Safety and Health at Work has established the priorities for OSH research in Europe for the next period, in the context of Europe 2020 strategy for smart sustainable and inclusive growth (Table 1.37).

Table 1.37. Synthesis of the OSH research priorities in the European Union

Research Priorities	**Expectations / Actions / Implications / Research Target**
1. Promoting good health	• Keeping people healthy and active for longer has a positive impact on productivity and competitiveness. Health and safety at work and OSH researches have a role to play in delivering smart, sustainable and inclusive growth ((EU-OSHA, 2013) report has been identified that a decisive scientific knowledge is still lacking!); • A detailed approach should be developed at the theoretical and pragmatic level, in order to identify exposure assessment methods to estimate the related risks and appropriate risk management approaches to design workplaces to make them as safe as possible could then be created; For some emerging risks there is insufficient knowledge available to make reliable risk assessments.
2. OSH in the context of new technologies (e.g. those needed for new energy policies, climate adaptation, future manufacturing)	• New technologies benefits have to be clearly visible and their potential risks have to be acceptable by society. This requires identifying and addressing stakeholder and public expectations and responding to their concerns in order to build confidence and to show that new technologies are well under control; • It is needed to identify and assess OSH risks associated with new technologies and integrating OSH aspects in the development of new technologies and processes.

3. Economic activity and occupational injury and illness	• Researches has to discover and understanding the role of economic factors in the etiology of workplace ill-health and the effects this has on the economic prospects for workers, enterprises, and society is crucial for policy development and to support decision making at enterprise and society levels.
4. OSH research findings has to be strongly translated into practical and accessible workplace solutions	• OSH research has to be focused on the transfer and translation of scientific knowledge into practical, accessible workplace solutions and interventions. • It is important to integrate OSH research in the development of new technologies and processes (prevention through design).
5. Risk and OSH communication	• These are closely related to the transfer and dissemination of research results (together with best practices of OSH and risk successful policies implementation). • Risk communication is particularly important in the context of new technologies where there are uncertainties regarding the potential risks. There is a need to strengthen risk communication research to identify efficient ways of delivering timely and appropriate information on OSH to various target audiences.

Within this priorities report (Macdonald, 2003; Thébaud-Mony at al., 2012; European Agency for Safety and Health at Work, 2013) there have been identified some specific research topics related to occupational risk assessment as:

- The research priority of creating reliable tools for quantitative risk assessment that will generate better quantitative data for the potency/potential identification of carcinogenic, mutagenic and sensitizing substances. In addition, there is a research need for the validation and improvement of models for worker exposure assessment: measuring, modeling and risk assessment;
- Job specific risk assessment tools need to be developed to ensure safe working environments and also to identifying OSH topics that training programs should be geared to address. This would facilitate the transfer of existing OSH knowledge to green technologies, and the development of job specific risk assessment for green jobs, as well as identifying OSH training needs;
- As a result of the increasing use of biotechnologies in the industrial sector, there is a need to develop tools for risk assessment and prevention measures.

EU priorities regarding occupational risks are formulated in OSHA report (European Agency for Safety and Health at Work) of January 2014. The report's objective was to identify priorities for OHS research in the coming years in accordance with the Europe 2020 strategy and the Horizon 2020 program. These priorities are:

- Occupational health and safety communication and risk communication: investigating the use of new technologies in OHS and developing good communication;
- Intervention research: evaluate the OSH interventions at all levels and risk communication;

- Globalization and the changing world of work: Changing organizations, new employment and work patterns, and new environmental, and OHS in small enterprises.

Occupational health and safety research for safe new technologies: risk in new technologies and information and communication technology: opportunities and risks in the working environment.

Aligning the organizations in Romania to the European directives would lead to improved working conditions and reducing work accidents. Accident situation in Europe (by selecting the relevant countries to this research) in 2011 is shown in Table 1.38.

Table 1.38. Number of accidents in Europe in 2011*

Country	Number of accidents 2011		Accident per 100.000 workers	
	serious	fatal	Serious	Fatal
Belgium	55.315	66	502,86	0,6
Germany	747.560	469	915	0,57
Spain	363.510	336	785	0,72
France	483.476	501	748	0,77
Portugal	81.730	180	778	1,26
Slovenia	12.449	19	622	0,95
Romania	28.100	273	127	1,24

* Source Eurostatt, online data code hsw_mi01, demo_gind

From the analysis of above data, we can see that the situation of Romania is an acceptable one, there are 28,100 serious accidents and 273 fatal accidents in the year 2011. The most worrying situation is recorded in Germany, where the number of serious injuries / accidents per 100,000 workers was 915. The number of these accidents is recorded at the European level.

Analysis of work accidents causes in Romania

The data used in this research are obtained from Romanian Labour Inspection, they are real data that shows the reality in the field. The author uses recent and actual data from 2011-2013. In the last years, the number of work accidents occurred in Romania fluctuated slightly from year to year, the peak being in 2008, with 5,110 cases, while in 2013 the authorities registered 3,627 cases. The work process is a complex system, structured on the following mutually interacting elements (Romanian Labour Inspection):

- The performers - workers involved in the execution of work tasks;
- The workload - all actions to be performed by means of production and under certain conditions, to achieve the aim of the work;
- Means of production – all the instruments of labor (plant, equipment, machinery, apparatus, tools, etc.) and objects of labor (raw materials, etc.) used in the workplace;
- Work environment - all physical, chemical, biological and psychological conditions in which one or more performers achieve their tasks.

The causes of accidents are analyzed by the work system elements, considering that an accident may occur by combining several causes. Data presentation is done by group of causes dependent of: work environment, work load, means of production and execution. Taking to the

analysis the period 2011-2013, the author presents the evolution of work accidents causes in Table 1.39.

Table 1.39. The evolution of work accidents causes in Romania

Group of causes	Causal elements	Total accidents (%)			Fatal Accidents (%)		
		2011	2012	2013	2011	2012	2013
Causes dependent of the performer	Performing improper work operations	37.7	37	40.4	36.2	29.4	35.1
	Fall from height or same level	27.5	29	27.2	15.2	14.4	10.5
	Omissions (failure to use protection means et al.)	17.4	16.9	16.3	18.1	23.9	20.5
	Exposure, outside work load, to hazardous or noxious factors	6.9	5.9	5.5	14.3	12.8	14
	Performing, outside work load, of hazardous operations	1.7	1.7	1.4	2.9	2.8	4.1
	Presence at work in poor psycho physiological conditions	0.9	0.8	0.9	3.8	6.7	2.3
	Other causes	7.9	8.7	8.3	9.5	10	13.5
Causes dependent of production	Physical causes	62.1	59	58.6	67.1	65.1	63.7
	Chemical causes	1.4	1.7	1.0	2.8	3.3	1.6
	Biological causes	0.1	0.5	0.3	0.0	0.7	0.0
	Other causes (static effort, forced positions, monotony of work)	36.4	38.8	40.1	31.1	30.9	34.7
Causes dependent on workload	Supervision, control	17.3	14.6	14.3	22.4	22.0	21.7
	Errors in preset work operations	13.3	11.7	12.4	10.6	9.9	10.8
	Omissions in preset work operations	11.4	10.8	12.1	18.0	7.1	6.7
	Shortcomings in working conditions	6.3	6.2	6.6	3.7	8.5	10.8
	Inadequate distribution of performers on workplaces	4.1	5.0	4.2	9.9	12.1	11.7
	Other causes	47.6	51.7	50.4	35.4	40.4	38.3
Causes dependent on work environment	Other causes	6.5	9.2	6.7	13.2	22.6	10.7
	Physical causes	2.2	1.4	1.5	6.1	3.2	1.3
	The special nature of the environment	1.8	1.4	1.2	0.9	3.2	1.3
	Psychosocial climate	1.0	1.1	0.9	2.6	1.1	4.0
	Chemical causes	88.5	86.9	89.7	77.2	69.9	82.7

In 2013 there were 3,627 work accidents, 14% fewer than in 2012. The year before, in 2012 there was a total of 4,187 people injured, 8% less than in 2011, when there were 4,010 people injured. Analyzing this trend is observed as the number of accidents experienced a decrease, the slope of decline is increasing. At present, the Romanian Labour Inspection statutory controls are numerous, increasing by 21% compared to the previous year. Basically, the organizations realize the importance of this field and also pushed by the national legislation they improve their working conditions and invest in occupational risk.

From the analysis of the above data it results that the main causes of work accidents presented on the elements of work system are:

- Performer: Performing improper work operations and omissions;

- Production: Physical causes;

- Workload: Omissions in operations preset and supervision work, control

- Labor: Causes of physical nature.

It is noted that the main causes of accident at work are dependent on the work operations, which are incomplete implemented or present a number of difficulties in practice. The causes of physical nature prevail on the elements: labor and production. Work operations and physical causes are interrelated, being causes that trigger each other in a real job. To reduce occupational accidents, the organizations need to invest in facilities and equipment to ensure optimal working conditions.

The conceptual model

Considering the causes dependent of the labor system, it can outline a conceptual model for improving the current situation. It can be seen that the work accident situation improved from one year to another. Based on the improvement shown nationally, the Figure 1.52 systematizes the conceptual model of continuous improvement and of the development of sustainable workplaces.

Based on the causes of the elements of the work system (causes dependent on the performer, the means of production, the workload and working environment) a series of measures are imposed to reduce work accidents (actions of informing and awareness of employers and employees, employee training, investment in working conditions, accessing European funds for the development of software tools to monitor the situation, improving the organization communication, implementation of international standards relating to health and safety at work). By adopting such measures in the system of work for sure the path to sustainable and healthy workplaces is created.

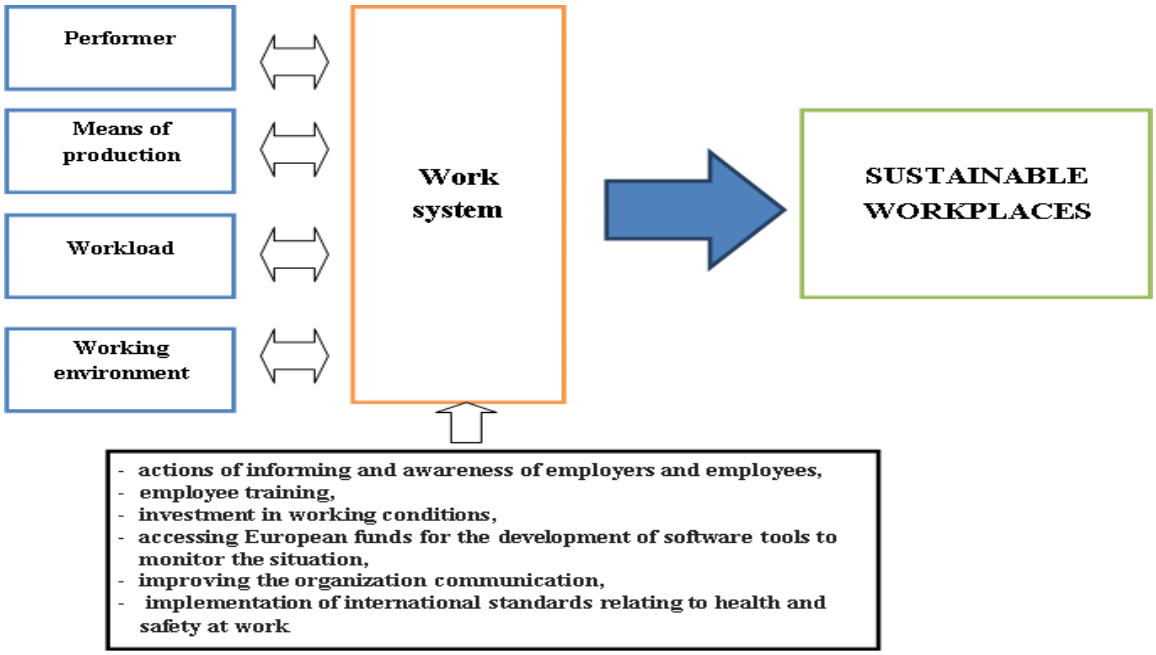


Figure 1.52. The conceptual model of continuous improvement and of the development of sustainable workplaces

Detailed, the causes dependent on the performer, the means of production, the work load and work environment, there were variations in the analyzed period. Given the structure of the causes of the accidents we must emphasize the implementation of actual measures that contribute to the improvement of the current situation (actions of informing and awareness of employers and employees, employee training, investment in working conditions, et al.). The future directions of work include: analysis of cases in other EU member countries and the development of a comprehensive database that contributes to the implementation of a procedure for cause's reduction.

1.4.6. Investigation of work accidents using information and communication technology

Sustainable development has a significant impact today in Romania and worldwide. In this context, risk assessment becomes mandatory for enterprises. This part analyzes the situation of occupational risks in the metallurgical industry in the European Union, Romania, and the United States and highlights the main causes for work accidents in Romanian metallurgical industry. The analysis covers the period 2009-2014. The data collected from Romania is compared to the data related to the European Union and the United States. Moreover, this section aims to present an occupational risk assessment tool, which is customizable for each area of activity. The development of healthy work places contributes to sustainable development (SD), which is on the agenda of many enterprises in Romania and abroad. Risk is a situation of fact, caused by a hazard, which occurs in an enterprise, and may adversely or positively affect the goals of the enterprise, including probability and opportunity (Ivascu, 2013). The complexity of the activities carried out in the metallurgical industry requires the use of a risk assessment framework. There are several tools and methodologies for this purpose, such as DACAR (Fan et al., 2011), CARE (Baru et. al., 2012), OIRA (European Agency, 2015). Even if the first step in artificial intelligence was taken in 1961, using cloud computing has gained widespread popularity in industry and academia. Scalable access and sharing of resources have contributed to a rethinking of business processes (Ali et al., 2015). The access to newly developed innovative tools contributes to a great extent to the reduction of occupational risks in different areas of activity and especially in the metallurgical industry. The specific nature of the work requires updating the methodology concerning occupational health and safety and developing add-ons for the platform already in use.

The evolution of metallurgical industry

The metallurgical sector is an essential ring in the EU industrial supply chain, because it produces components and finished goods used in other production sectors. In 2010, the Romanian metallurgical industry achieved an added value of about 562 million euros (0,93% of the EU total) with a labor productivity of approximately 14 800 Euro/employee (i.e. 25% of the EU average). In 2013, it provided jobs for around 10 % of the EU-27 industrial workforce. In 2014, there was a decrease in jobs, since in 2009 the metallurgical sector covered approximately 12 % of the total number of jobs in the EU-27 (European Agency, 2015).

The data used in the analysis of accidents at work were retrieved from the European Statistics on Accidents at Work (ESAW) (European Agency, 2015) and from the Romanian Labor

Inspection (Romanian Labor Inspectorate, 2015). Current statistics estimate that there are about 160 million occupational disease cases every year worldwide, 30 – 40 % of these evolving towards chronic conditions, and 10 % causing permanent incapacity for work.

Starting from the total number of work accidents in Romania, this section presents below the evolution of accidents in the metallurgical industry, in order to highlight the rate of occupational risks in this sector. Figure 1.53 shows the evolution of work accidents in Romania. The figures for 2014 are 30 % lower than those for 2009. This may be due to the evolution of technology; currently, there is a permanent concern for the development of healthy work places that contribute to sustainable development.

In terms of the frequency index, the situation in Romania is shown in Figure 1.54. The frequency index, Fi, is defined as the number of injured people per 1 000 workers:

$$\mathrm{F_i} = \frac{\text{Work accident}}{\text{Number of workers}} * 1\,000 \qquad (1)$$

In 2013, Fi was 0.79 ‰ for the total number of injured people, 8,1 % lower than in 2012, when it was 0,86 ‰. The decrease in Fi is due to a fall in the number of accidents, but also in the number of workers. As shown in the literature, the economic crisis affected the Romanian economy (Dobrota et al., 2015). In 2010, there was a negative growth (- 7.1 %) compared to the previous year; the trend was maintained in 2014 (Dobrota et al., 2015).

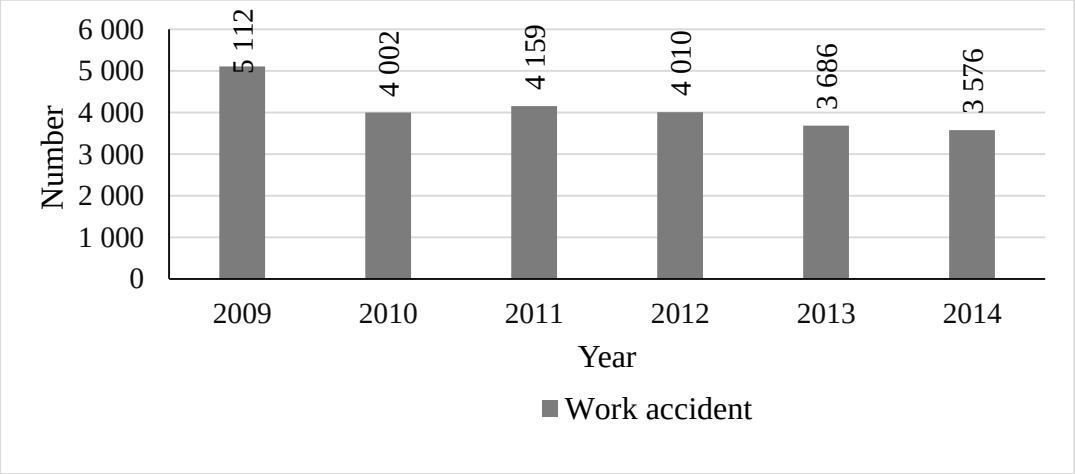


Figure 1.53.The evolution of accidents in Romania between 2009 - 2014 (Romanian Labor Inspectorate, 2015)

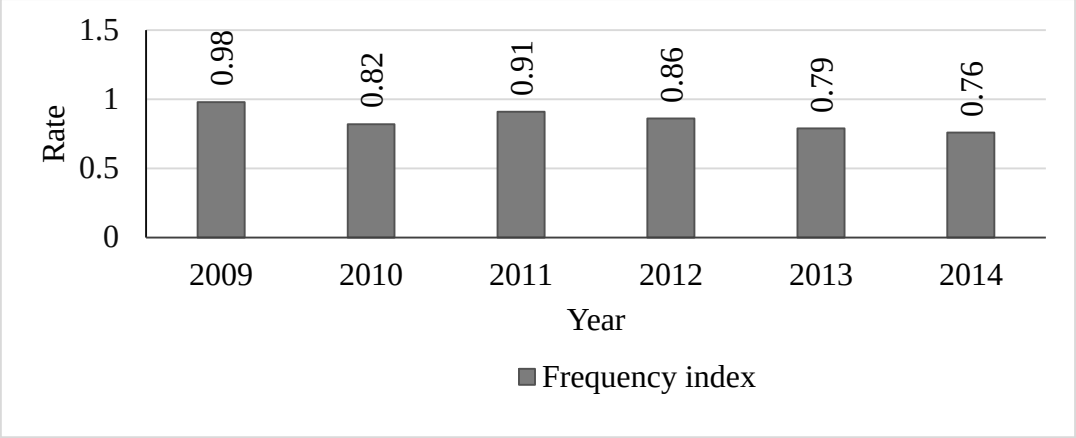


Figure 1.54. The frequency index related to accidents in Romania between 2009 - 2014 (Romanian Labor Inspectorate, 2015)

The number of fatalities decreased, reaching a value of 199 in 2014. In 2013, there were 215 fatalities, 35.6% less than in 2012, when there were 334 fatalities. Their evolution is shown in Figure 1.55. The downward trajectory in recent years was due to the economic situation (because of the economic crisis, many enterprises went bankrupt), but also to the sustainable management systems implemented by many companies.

The frequency index of fatal incidents, Fi_f, has been defined as the number of fatalities per 1 000 workers:

$$\mathrm{Fi_f} = \frac{\text{Incident fatalities}}{\text{Number of workers}} * 1\,000 \quad (2)$$

Fi_f was 0.05 ‰ total fatalities, 28.5 % lower than in 2011 when it was 0.07 ‰.

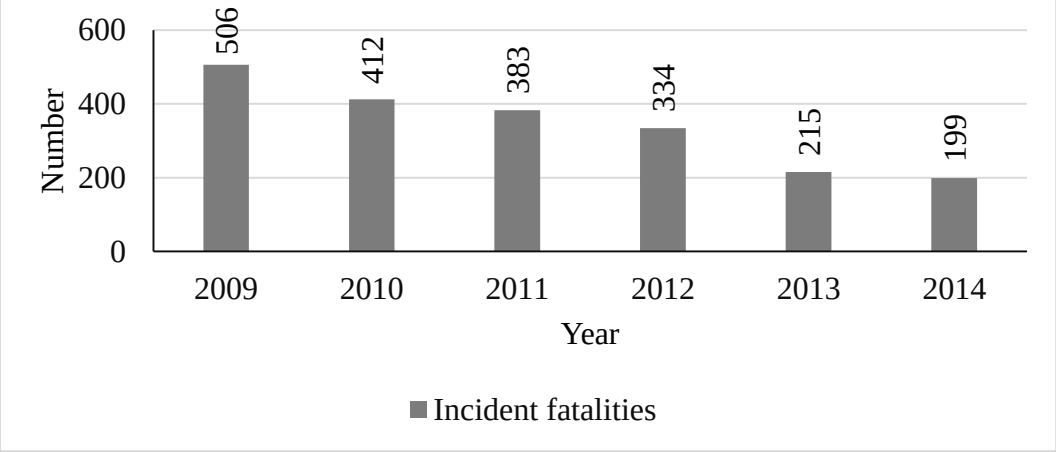


Figure 1.55. The evolution of fatal accidents at work in Romania between 2009 - 2014

Table 1.40 shows an overview of work accidents in the metallurgical industry. The data highlights that the number of accidents at work has been decreasing as of 2012. In 2014, there were fewer work accidents than in 2012 by 30.8 %. Most work accidents occurred in 2009, i.e. 169. In terms of fatal work accidents, there is no downward trajectory, but a series of irregular variations; the highest figure was recorded in 2009, i.e. 7 deaths. In 2013, there were 6 fatalities,

accounting for 2.8 % of the total number of fatalities in the entire Romanian economy, 100 % more than in 2012, when the number of fatalities was 3. The frequency index in Romania is 0.79 ‰.

Table 1.40. Work accidents in the metallurgical industry in Romania between 2009 – 2014 (Darabont et al., 2001)

Dimension	**Value**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
NAW	Value	169	83	111	107	100	74
	Percentage / %	4.9	2.1	3	2.4	2.2	2
NFA	Value	7	5	4	3	6	5
	Percentage / %	4.2	2.1	2.2	3.22	2.8	2,6
Fi / ‰		2,1	0.80	1.2	1.7	0.17	0.15
Fi_f / ‰		0,21	0.12	0.06	0.08	0.17	0.10
Total number of employees in the metallurgical industry		61 236	64 203	59 213	61 259	35 757	32 050
The total number of employees in Romania		-	-	-	4 840 322	4 693 585	4 753 821

Legend: F_i – frequency index, Fi_f - frequency index of fatal incidents, NAW - Number of accidents at work, NFA - Number of fatal accidents

Occupational risks in the European Union

European work places are undergoing constant development under the influence of economic, social and environmental changes. The situation of work accidents in the European Union (EU) is presented in Table 1.41.

Table 1.41. Work accidents in the metallurgical industry in the European Union between 2012-2014

Dimension	**2012**	**2013**	**2014**
NAW / No	29 912 064	32 714 238	31 105 271
NAW / %	16.8	18.6	17. 2
Fi / ‰	0.74	1.2	0.20
NAF / No	998 876	3 567 670	2 990 600
NAF / %	0.33	1.09	0.9
Fi_f / ‰	0.02	0.13	0.01

Source: European Agency for Safety and Health at Work, 2015

Occupational risks in the United States

In the United States (U.S.), severe occupational injuries and illnesses decreased to a rate of 109.4 cases per 10 000 full-time workers for the private sector and state/local government in 2013. The situation of occupational risks U.S. metallurgical industry is shown in Table 1.42. The number of employees was 3 883 600 in 2010, it decreased by 1% in 2011, by 2% in 2012, and it decreased by 3.6% in 2013 compared to 2010.

Table 1.42. Work accidents in the metallurgical industry in United State

Dimension	**2011**	**2012**	**2013**	**2014**
NAW / No	5 864	6 403	6 533	5 967
NAW / %	15.1	16.6	17.1	15.9
Fi / ‰	0.04	0.05	0.05	1.58
NAF / No	194	231	267	713
NAF / %	0.5	0.6	0.7	1.9
Fi_f	0.001‰	0.001‰	0.02‰	0.18‰

Source: Bureau of Labour Statistics for United State, 2015

Computational model

In a previous research project (Ivascu, 2013), it was conducted a comparative analysis of the risk assessment methods used today; the proposed approach is based on the research results we obtained and discusses the possibilities of improving the most widely used risk assessment method in Romania (Amza et al., 2012). For the development of the OnRisk Web platform, we used the WampServer and Xampp development web environment. The OnRisk platform integrates the following scripts: identification, evaluation, treatment, report and innovation (Figure 1.56).

Figure 1.56. OnRisk Platform

Considering the data from Table 1.40 this section identifies below the factors that cause accidents at work. It was applied this software solution on ten enterprises in the metallurgical industry to identify the main causes of work accidents. The results obtained are summarized in Table 1.43. There were identified several risk factors during the application of the computational model on those ten companies in the metallurgical industry such as: noise, vibrations and radiation. The main risks associated with those sources of danger are: hearing loss, psychological disorders, tinnitus, cardiovascular adverse effects, breathing and digestion.

Table 1.43. Main causes of work accidents identified using the OnRisk solution

Cause dependence	Name
Causes dependent on the worker	Inadequate performance of work operations, Falls from height
	Omissions in the work process
	Exposure, outside of work tasks, to hazardous or harmful factors
Causes dependent on the means of production	Inadequate equipment
	Exceeding the waiting times
	Air, soil quality
	Previous illness
Causes dependent on the work task	Shortcomings of working procedures
	Errors in presetting of work operations
	Shortcomings related to the occupational safety and hygiene

Of all factors presented in Table 1.43, pollution is a cause of work accidents in the metallurgical industry which is very difficult to deal with. Pollution refers to pollution in enclosed spaces. Even if the volume of production non-ferrous metallurgy is smaller than in the case of ferrous metallurgy, the harmfulness of the former is generally higher than that of the latter, while its impurities are toxic. Therefore, occupational risks in non-ferrouse metallurgy lie in a high-risk, red area. Pollution in the work environment and its effects require special attention.

Results and limitations

The data presented in this section leads to the following results:

- The downward trajectory of work accidents is the result of the SD actions adopted (a previous study shows that most enterprises are concerned with SD (Ivascu et al., 2014)).
- In 2014, the number of accidents at work is significant in the three areas analyzed (Romanian, The EU, and the US).
- Fi_f, does not follow a downward trajectory in the areas analyzed, but an irregular one, with ups and downs.
- Romanian's trajectory is similar to the one of the EU in term of the values of Fi_f and F_i.
- The significant causes of work accidents are those dependent on the worker. The causes dependent on the means of production are dominated by pollution, which is one of the most common in this area.
- The applications are hosted by a cloud service provider and made available to customers over a network.

The limitations in the analysis are restricted to the lack of data related to Romania (some data between 2009 and 2011) and to cases of undeclared work. The limitation of the software solution is the fact that the platform is based on the assessment of individual risk factors but it does not take into account their combined effect.

1.4.7. Investigating occupational diseases in the metallurgical industry

The section presents the trends in the evolution of occupational diseases in Romania in comparison to the EU and the US, as incidence of occupational diseases, their interrelationship

with the exposure to occupational risk factors in the working environment, the dynamic changes over time of the traditional structure and of the hierarchy framework of employees' check-up regarding the risk factors. The analysis covers the period 2009 - 2015 and was made in quantitative terms (statistical data) and qualitative terms (study concerning the causal factors of the employee's work environment). The data are presented as absolute figures and the average annual incidence rates are presented per 100 000 people employed in this industry.

The human body is a complex system of motility habits and skills and thus work efficiency is de-pendent on the physical and psychological state of the human resource (Cioca et al., 2015). Metallurgical industry (Dobrota and Ungureanu, 2015) is one of the most demanding industries, in terms of working conditions with increased risk factors, being vital to us to know the evolution of occupational diseases in order to prevent the risk of injury and to make the employees' work more efficient (Amza and Dobrota, 2015). It is an essential ring in the European Union (EU) industrial supply chain, as it produces components and finished goods used in other production sectors. Therefore, this part aims to identify the trajectory of the metallurgical industry in terms of occupational diseases, for the period 2009 – 2015.

In Romania, the metallurgical industry is privatized 100 %, and the share of foreign capital is about 80 %. In 2010, the Romanian metallurgical industry achieved a benefit of about 562 million Euros (0.93 % of the EU total) with a labour productivity of approximately 14 800 Euro / employee (i.e. 25 % of the EU average). In 2013, it provided jobs for around 10 % of the EU - 27 industrial workforce. In 2015, there was a decrease in jobs, since in 2009 the metallurgical sector covered approximately 11 % of the total number of jobs in the EU. The metallurgical industry provided 12 % of all jobs in the industrial sector (European Agency for Safety and Health at Work, 2015).

Occupational diseases in Romania between 2009 and 2015

According to the National Institute of Statistics of Romania, the incidence of occupational diseases per type of activity shows that, in 2015, the most cases of diseases were reported in the construction industry (38.70 % of the total reported cases), the metalliferous ore extraction (12.54 %), and the manufacture of motor vehicles for road transport, trailers and semi-trailers (12.40 %) (National Institute of Statistics, 2015; Labour Inspection of Romania, 2015). In 2015, there were 335 cases of musculoskeletal disorders, 246 cases of silico-sis, and 61 cases of bronchial asthma. Occupational diseases caused by musculoskeletal disorders top the list in Romania as they do worldwide (Labour Inspection of Romania, 2015). The evolution of the number of new reported cases of occupational diseases in Romania for the period 2010 – 2015 is shown in

Figure 1.57, in which only the new cases reported are considered, without the cases reported in other years, for which the disease has recurred or worsened itself. It can be noticed that professional morbidity vary widely in recent years, the highest level being recorded in 2009, with approximately 27 % more occupational illnesses than in 2015 (National Institute of Statistics, 2015; Labour Inspection of Romania, 2015).

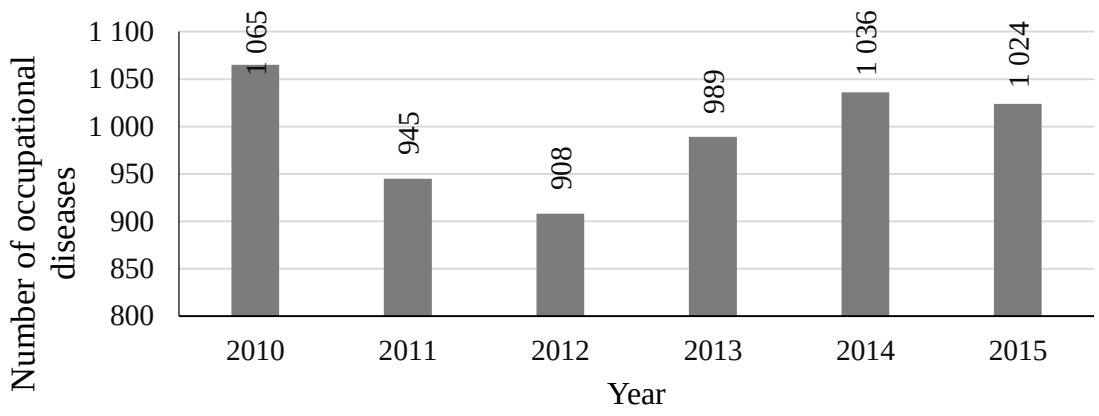


Figure 1.57. The evolution of the number of new occupational diseases reported in Romania between 2010 and 2015

The evolution of the number of occupational diseases reported in the metallurgical industry in Romania is shown in the below figure.

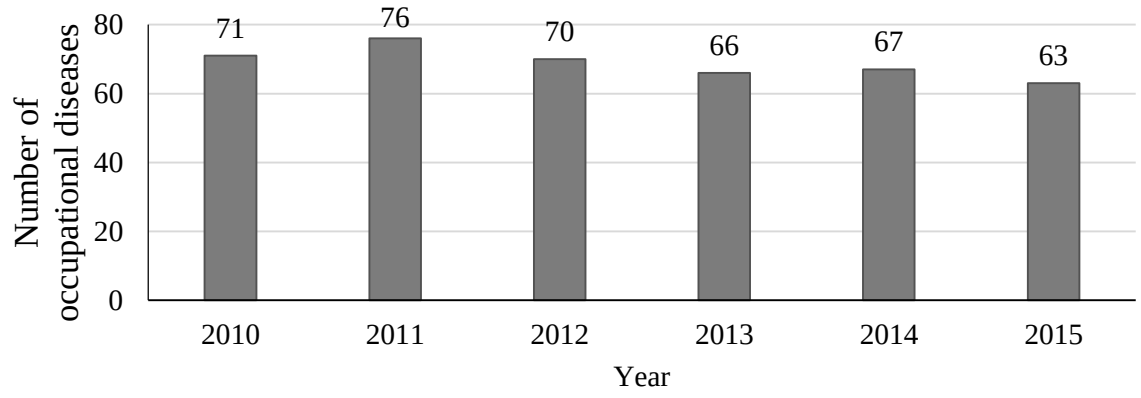


Figure 1.58. The evolution of the number of new occupational diseases in Romania in the metallurgical industry between 2010 and 2015

In 2014, the metallurgical industry in Romania recorded 67 new reported cases and it ranked fifth, according to individual branches of industry, representing 6.5 % of the total reported cases (National Institute of Statistics, 2015; Labour Inspection of Romania, 2015). The construction industry came first with 370 new reported cases, representing 35.70 % of the total cases in Romania.

The evolution of the number of new cases is in decline, with a decrease of approximately 17 % in 2015, as compared to 2011. The most numerous new cases in the metallurgical industry were recorded in 2009, i.e. 101 new reported cases, representing 7.21 % of the total number of cases reported in Romania (National Institute of Statistics, 2015; Labour Inspection of Romania, 2015).

The total incidence index is an indicator that is used to identify the condition and efficiency of the sector analyzed. The incidence index (1) is defined as the total number of

declared cases of diseases at national level (N_{TAD}) divided by the total number of employees (N_T) per 100 000 workers:

$$I_i = \frac{N_{TAD}}{N_T} * 100\ 000 \qquad (1)$$

The incidence index for the metallurgical industry (2) is defined as the total number of declared cases of diseases in the metallurgical industry (N_{MIAD}) divided by the total number of employees (N_T) per 100 000 workers:

$$I_{imi} = \frac{N_{MIAD}}{N_T} * 100\ 000 \qquad (2)$$

Table 1.44 shows an overview of the occupational morbidity in Romania, emphasizing the data related to the metallurgical industry. The data show that the number of new cases of illnesses in the metallurgical industry is between 6.15 % and 8,04 % out of the total number of new cases reported in Romania.

Since 2011, there has been a decrease in the number of new cases due to the new technology that reduces the effort and the harmful conditions of work and NOD decreases the most in 2015 with 18 %. In Romania, the incidence index was 21.53 %000 in 2015, with 4.8 % lower than the previous year.

Table 1.44. Occupational morbidity in the metallurgical industry in Romania between 2010 and 2015

Dimension / Value		2010	2011	2012	2013	2014	2015
NOD	Value	1 065	945	908	989	1 036	1 024
NODMI	Value	71	76	70	66	67	63
	Percentage / % of NOD	6,67	8,04	7,70	6,67	6,46	6,15
I_i / %000		22,30	19,63	18,76	21,07	21,79	21,53
I_{imi} / %000		1,48	1,57	1,44	1,40	1,40	1,33
Number of employees in the metallurgical industry		64 203	59 213	61 259	35 757	32 050	32 123
Total number of employees in Romania		4 774 000	4 812 000	4 840 322	4 693 585	4 753 821	4 754 896

Legend: NOD - The number of new occupational diseases reported in Romania, NODMI - The number of new cases of occupational diseases reported in the metallurgical industry, I_i – the total incidence index in Romania, I_{imi} – the incidence index in the metallurgical industry

Occupational diseases in the European Union

In Europe, musculoskeletal disorders are the most common health problems related to work, affecting millions of workers. In the European Union, 25 % of workers suffer from backaches

and 23 % report muscular pains (National Institute of Statistics, 2015; Labour Inspection of Romania, 2015; Health and Safety Executive, 2015). In the metallurgical industry, most workers suffer from bronchial asthma and silicosis, i.e. approximately 62 %. The situation in the EU metallurgical industry is shown in Table 1.45. The metallurgical industry represents 26 % of the total production value and 11 % of GDP (Gross domestic product) (Health and Safety Executive, 2015). The incidence rate of occupational dis-eases has a downward trajectory, registering in 2015 a value of 22.43 %000, due to a great concern within the EU for developing the 2020 Strategy for the development of sustainable job places.

Table 1.45.The occupational diseases in the EU metallurgical industry between 2012 and 2015

Dimension	2012	2013	2014	2015
NODMI	14 340	13 231	12 300	12 180
I_i / %000	24.34	23.47	22.61	22.43

Source: European Agency for Safety and Health at Work

OCCUPATIONAL DISEASES IN THE UNITED STATES

In the United States (US), on an industrial level, it is estimated that approximately 1.2 million people who worked in 2014 / 2015 suffered from an illness caused or aggravated by the work place, and 35 % of those were reported cases. The situation of the occupational diseases in the metallurgical industry in the US is shown in Table 1.46. In the US, about 70 % of the new cases of occupational diseases, for the year 2014 / 2015, were musculoskeletal or stress disorders, depression, or anxiety (Health and Safety Executive, 2015).

Table 1.46. The occupational diseases in the US metallurgical industry between 2012 and 2015

Dimension	2012	2013	2014	2015
NODMI	4 010	3 860	3 765	3 761
I_i / %000	19.87	19.21	18.87	18.86
I_{imi} / %000	2.31	1.98	1.88	1.86

Source: Health and Safety Executive

Results and limitations

Comparing the situation of EU-28, US, and Romania for 2008 and 2015, in term of the incidence index in the metallurgical industry, I_{imi}, it is observed that in 2015, the EU value drops by 16 %, in US falls by 9 %, and in Romania decreases by 7 % (Figure 1.59).

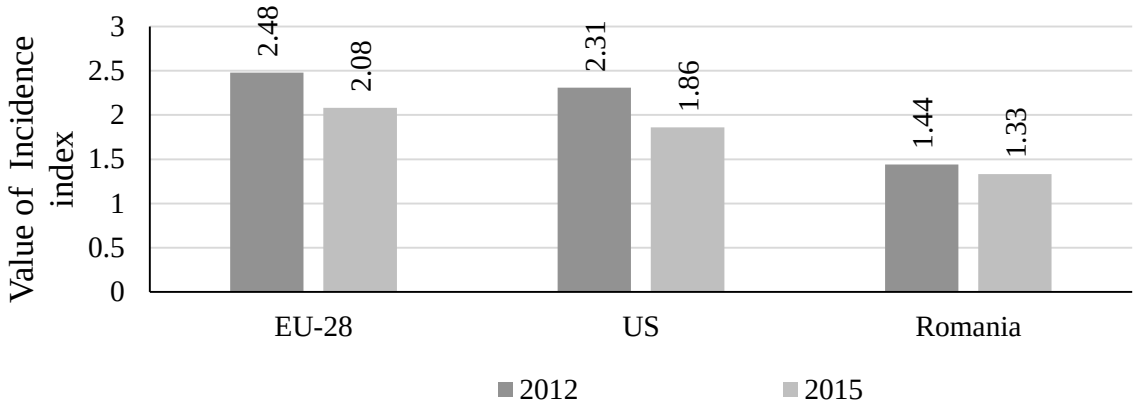


Figure 1.59. The evolution of the incidence index in the metallurgical industry between 2012 and 2015 in EU-28, US, and Romania

Considering the situation shown above, the primary hierarchical framework for controlling the employees' exposure include the following: anticipation, recognizing risks, controlling risks education, and the legislation in force (Figure 1.60).

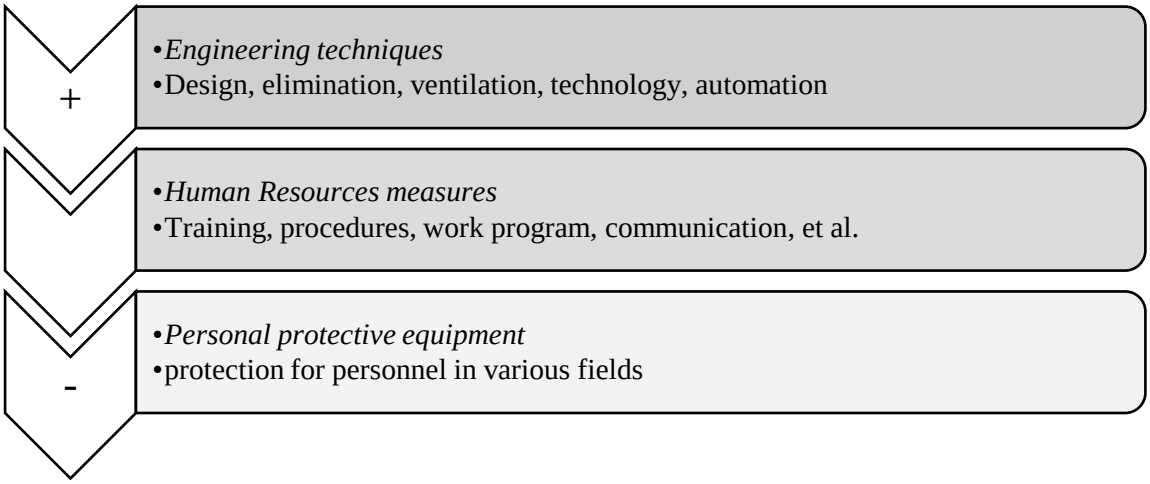


Figure 1.60. The preliminary hierarchical framework for controlling the worker's exposure to danger sources

On an efficiency scale of the methods (noted from + to -), the engineering techniques are gaining value, being in antithesis with the employees' equipment which should bring additional safety. The data analysis presented in the previous sections leads to several results, such as:

- In 2015, there was a decrease in the metallurgical industry by 7.3 % in the US and by 15.1% in the EU - 28, in comparison to 2012, due to the inclusion of new objectives in the 2020 Strategy.
- The decrease in the incidence of occupational morbidity is due to improved working conditions (due to technological developments and the legislation in force).
- From the perspective of the limitation, the decrease in the incidence of occupational morbidity may also imply that some of the cases are not even reported.

1.4.8. Occupational accidents assessment by field of activity and investigation model for prevention and control

The rate of occupational accidents is increasing, leading to a number of organizational deficiencies. For European Union (EU), the non-fatal accident number in 2017 was 3,315,101. An increase in the number of accidents is recorded in many of the member states. In addition, the increase in accidents tends to focus on certain sectors and is due more to the increase in the incidence rate than the increase in the workforce. Companies in these industry sectors have also implemented less intensive prevention practices than firms in other sectors. Performing a statistical evaluation of non-fatal and fatal accidents is an important one. This assessment helps managers understand the importance of implementing prevention and control methods across organizations. For this research, we used series of data obtained from the Romanian National Institute of Statistics (NIS), Labor Inspection in Romania, and Eurostat of the European Commission. Data series evaluations were conducted for the EU and Romania. A qualitative assessment of the industry data series had been carried out. Furthermore, T-tests and analysis of variance analysis (ANOVA) were performed to identify the relationships between the frequency index of fatal and non-fatal accidents, and the categories chosen. The values obtained for men were significantly higher than those of female workers. Based on the results of the qualitative assessment and European and national strategies, an experimental model for the prevention and control of occupational accidents is proposed. At the end of this section, the situation of labor accidents in Romania and Bulgaria, two EU member states, is assessed in the agriculture, forestry and fishing, manufacturing, construction and transport, and storage sectors. A series of trends are presented for the period 2018–2020. The results obtained from the evaluation of the data series represent an important core of the Romanian Labor Inspectorate for the development of strategic actions.

From the perspective of global sustainable development, occupational health and safety (OSH) is an essential issue. For OSH, workplace accidents in the European Union are the most important areas of action of the European Union's (EU's) social policy. The EU's commitment to improving working policies began in 1951, with the signing of the treaty establishing the European Coal and Steel Community (ECSC). This treaty was subsequently extended to all places of work by signing the Treaty of Rome. In 1987, the Single European Act opened a new chapter emphasizing the importance of OSH in the workplace. In 2000, the Lisbon European Council developed the "Creating more and better jobs" strategy and set out the actions and targets to be followed (European Statistics on Accidents at Work, 2018; National Institute of Statistics—Romania, 2018). Another step has been taken by developing the European Commission's "Improving quality and productivity at work: Community strategy 2007–2012 on health and safety at work." This action has set the overall target of achieving a 25% reduction in the overall incidence rate of work accidents (the number of workplace accidents per 100,000 workers) in the EU-27 by 2012. This could only be achieved through a series of national strategies addressing the most common and severe risks and the most vulnerable sectors of activity, businesses, and workers. The EU strategic framework for workplace health and safety 2014–2020 integrates a series of actions to prevent occupational hazards. There is an intense global concern over policies to reduce workplace accidents and improve working conditions. Emphasis is placed on risk prevention and mitigation of the consequences of

occupational hazards so that each EU member country develops sustainably (The Minister of Labour and Social Justice, 2018).

From the perspective of the terms used in OSH, the most important implications are presented next. By definition, an accident at work, in accordance with the European Statistics on Accidents at Work (ESAW) methodology, is a discrete event that occurs during organizational activity and results in physical or mental injury to the worker. Fatal accidents at work are defined as those that lead to the victim's death within one year of the accident. Non-fatal workplace accidents or serious accidents at the workplace involve at least four complete days of absence from work. As a consequence, non-fatal accidents at work cause considerable damage to the organization's workers and their families. Workers involved in non-fatal accidents will live with permanent disabilities, leave the labor market, or change their workplace. As a macroeconomic effect, work-related accidents can lead to the loss of a considerable number of working days in the national and European economy (Work Inspectio, 2018; Jørgensen, 2016).

Starting in 2015, for EU, the fatal accident rate has started to decline due to preventive actions at the member state level (Day et al., 2012). Previous studies on the explanation of professional accidents showed that there were a number of them based on causes that had not been steadily intervened upon (Bellamy, 2010; Masi, et al., 2015; Hadjimanolis et al., 2015; Cagno et al., 2016). A study by Day et al. (2012) showed that stress and overloading the employee contributed to the occurrence of many accidents at work (Bonafede et al., 2016). Occupational risk assessment was needed to be performed for each business to be effective (Cunningham et al., 2015; Sgourou et al., 2010; De Koster et al., 2011; Liu et al., 2014; Wu et al., 2008). Occupational accidents are a major challenge for some sectors of the economy (e.g., agriculture; industry and construction (except mining); services of the business economy; agriculture, forestry and fishing; crop and animal production; hunting and related service activities; and forestry and logging). Most workers face many risks and the number of accidents is high in developed and developing countries. In EU, the number of work-related accidents in 2017 reached 3,315,101. In 2017, in Germany the number of non-fatal accidents was 862,983 accidents, and in France there was 749,670 accidents. In terms of fatal accidents, France ranks first with 595 fatal accidents, Italy ranks second with 481 accidents, and Germany with third place with 413 accidents (European Statistics on Accidents at Work, 2018; National Institute of Statistics—Romania, 2018).

This research is structured in three directions—the first part presents the existing situation in EU, the second part presents the situation existing in Romania, and the third part evaluates the European and national strategies in the field of occupational safety and health. The novelty of this research consists in presenting the inventory of the risk situation in Romania compared to the EU and the proposed framework for prevention and control which takes into account the most important entities that influence the organizational policies related to occupational health and safety. We conducted an ANOVA analysis to highlight the link between the various variables considered in this research. To support this research, we evaluated a series of preventive and control models, on the basis of which we proposed one for Romania (depending on the national strategy that was in accordance with the European strategy).

Materials and Methods

This section is based on the qualitative assessment of the statistical data for 2013–2017. An assessment of non-fatal and fatal accidents in European Union and Romania is carried out. The purpose of this assessment is to highlight Romania's situation in relation to the European Union, and to propose strategic actions to improve the national situation. In the evaluation, statistical data series and four basic indicators were used. Statistical data refers to non-fatal and fatal accidents at work in the European Union (EU) and in Romania; the data series in the statistics used were obtained from the National Institute of Statistics of Romania (NIS), Labor Inspection from Romania, and Eurostat of the European Commission (Kim et al., 2016; Jennifer et al., 2018; Mehmood et al., 2018; Long et al., 2018). The data in these series were declared accidents within the enterprise. Some series may give some discontinuities because the data did not exist. The following indicators are used in the present research—rate of incidence frequency index of labor accidents, the frequency index of fatal accidents, the average duration index, and the index of severity.

The incidence rate was calculated as the number of injuries per 100,000 employees (the indicator being used in the EU situation assessment). The frequency index of non-fatal accidents is defined as the number of injuries per 1000 workers. The frequency index of fatal accidents is the number of injuries per 1000 workers.

The average durability index highlights the number of days lost, on average, by an injured person in the workplace. The severity index is defined as the total number of days of work incapacity per 1000 employees. T-test and ANOVA analysis were used to verify the statistical results. Following the evaluation, a strategic model for improving the current situation is proposed based on the national and European strategy. The EU Strategic Framework on Health and Safety at Work 2014–2020 and the National Occupational Safety and Health Strategy for the 2017–2020 are used for the model proposed for the prevention and control of work accidents. In order to highlight the situation of Romania compared to the situation existing in the EU, a comparative assessment is presented on the Romanian and Bulgarian activity domains. Based on the presented assessment, a series of accident trends are presented for the period 2018–2020.

The situation of work accidents in the EU

This section presents the situation at EU level, assessing non-fatal and fatal accidents.

Figure 1.61 presents the situation of work accidents for the period 2013–2017. From the perspective of work accidents, it can be noticed that in 2013, the number of non-fatal accidents was 3,127,546, the lowest level of accidents registered in 2013–2017. In 2015, there were approximately 3.21 million non-fatal accidents that led to at least four calendar days of absence from work. Since 2016, labor accidents had started to increase, reaching 3,315,101 in 2017.

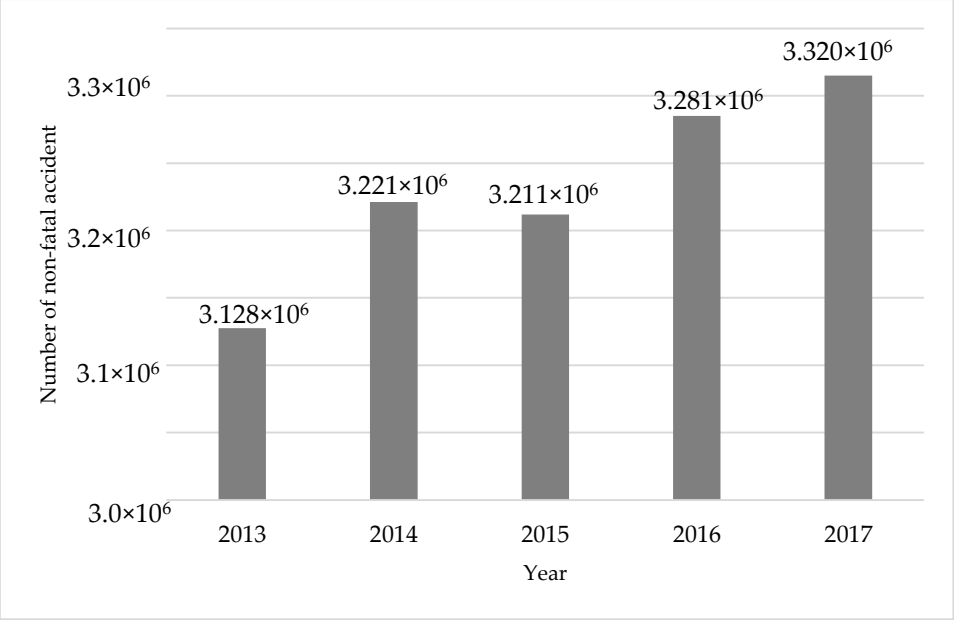


Figure 1.61. The non-fatal accident situation in the European Union during 2013–2017
Source: European Statistics on Accidents at Work, 2018

Evaluating the distribution of non-fatal accidents in EU member countries, Table 1.47 presents the accident situation for 2013 and 2017. Also, the dynamics of the variation (DV) is presented. The highest level of non-fatal accidents is recorded in Germany, followed by France, Spain and Italy. By realizing the dynamics of accidents, in percentages, by comparing the year 2017 to 2016, it can be noticed that Hungary recorded the highest dynamics of the variation of +45.16%. France has recorded an increase in accidents in 2017 compared to 2013, with a variation dynamics of +32.12. Greece has the highest fall in accidents in 2017 compared to 2013, with a value of −58.79% for DV. There are no datasets for Iceland (Kim et al., 2016; Jennifer et al., 2018). The number of non-fatal accidents has increased as a result of the development of some areas of activity, consumption intensity, infrastructure development, and other arguments (National Institute of Statistics—Bulgaria, 2019; Eurostat European Commission. Accidents at Work Statistics—Romania, 2019; Eurostat European Commission. Accidents at Work Statistics—Bulgaria, 2019; Pedro et al., 2012; Wu et al., 2018; Independent Evaluation of the ILO's Strategy on Occupational Safety and Health, 2019; Hämäläinen, 2017; Cioca, and Ivascu, 2017). Consumers' needs are becoming ever more intense and diverse, so that business sectors develop in line with consumer demands (Wu et al., 2018). Fields of activity develop and increase their activity capacity so that the number of accidents can increase (Wu et al., 2018).

Table 1.47. The distribution of non-fatal accidents in European Union (EU) member countries

Country	2013	2017	DV	Country	2013	2017	DV
Belgium	56,405	70,674	+25.3%	Hungary	18,899	27,434	+45.16%
Bulgaria	2164	2188	+1.11%	Malta	2601	1818	−30.1%
Czech Republic	44,070	45,282	+2.75%	Netherlands	152,214	81,165	−46.68%

Denmark	55,931	49,439	−11.61%	Austria	64,646	62,902	−2.7%
Germany	852,061	862,983	+1.28%	Poland	77,339	84,037	+8.66%
Estonia	6175	6354	+2.9%	Portugal	123,137	135,033	+9.66%
Ireland	18,049	14,088	−21.95%	**Romania**	**3,453**	**4,188**	**+21.29%**
Greece	9676	3987	−58.79%	Slovenia	12,537	12,162	−2.99%
Spain	370,176	432,052	+16.72%	Slovakia	8741	9814	+12.28%
France	567,407	749,670	+32.12%	Finland	47,432	41,106	−13.34%
Republic of Croatia	11,709	13,263	+13.27%	Sweden	36,188	37,858	+4.61%
Italy	329,404	295,967	−10.15%	United Kingdom	243,798	227,165	−6.82%
Cyprus	1529	1900	+24.26%	Iceland	1,787	–	–
Latvia	1707	1810	+6.03%	Norway	22,807	10,150	−55.5%
Lithuania	3043	3541	+16.37%	Switzerland	86,039	87,386	+1.57%
Luxembourg	7055	7152	+1.37%				

Source: European Statistics on Accidents at Work, 2018

From the perspective of the fatal accidents that occurred in the European Union during the period 2013–2017, Figure 1.62, it can be noticed that in 2013, the number of accidents was 3674, a fairly high level. Until 2015, the number of fatal accidents was on the rise, and from 2016 the number of fatal accidents had started falling. In 2015, the number of fatal accidents was 3876, or about 828 non-fatal accidents for each fatal accident. There was a slight decrease in the total number of non-material workplace injuries in the EU-28 between 2014 and 2015, with about 9118 fewer (equivalent to a 0.3% reduction). In contrast, there were 102 fatal accidents in the EU-28 in 2015 compared to 2014 (equivalent to a 2.7% increase).

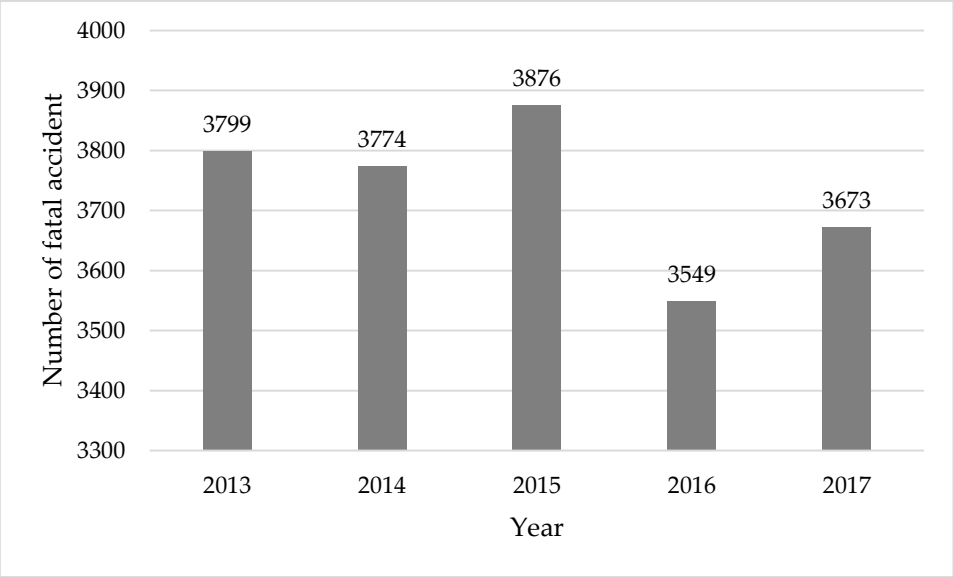


Figure 1.62. Situation of fatal accidents at the level of the European Union during 2013–2017

In terms of the distribution of fatal accidents for EU countries, Figure 1.63, it can be noticed that France, Italy and Germany are the countries with the most fatal accidents. In France, the number of fatal accidents in all sectors of activity was 595 and in Italy 481 in the year 2017. The lowest variation was in Cyprus, where the number of fatal accidents in 2017 reached 5 compared to 2013 when 9 accidents occurred (Hadjimanolis, 2015). The highest increase in fatal accidents was recorded in Luxembourg, where 22 accidents occurred in 2017 compared to 6 accidents in 2013.

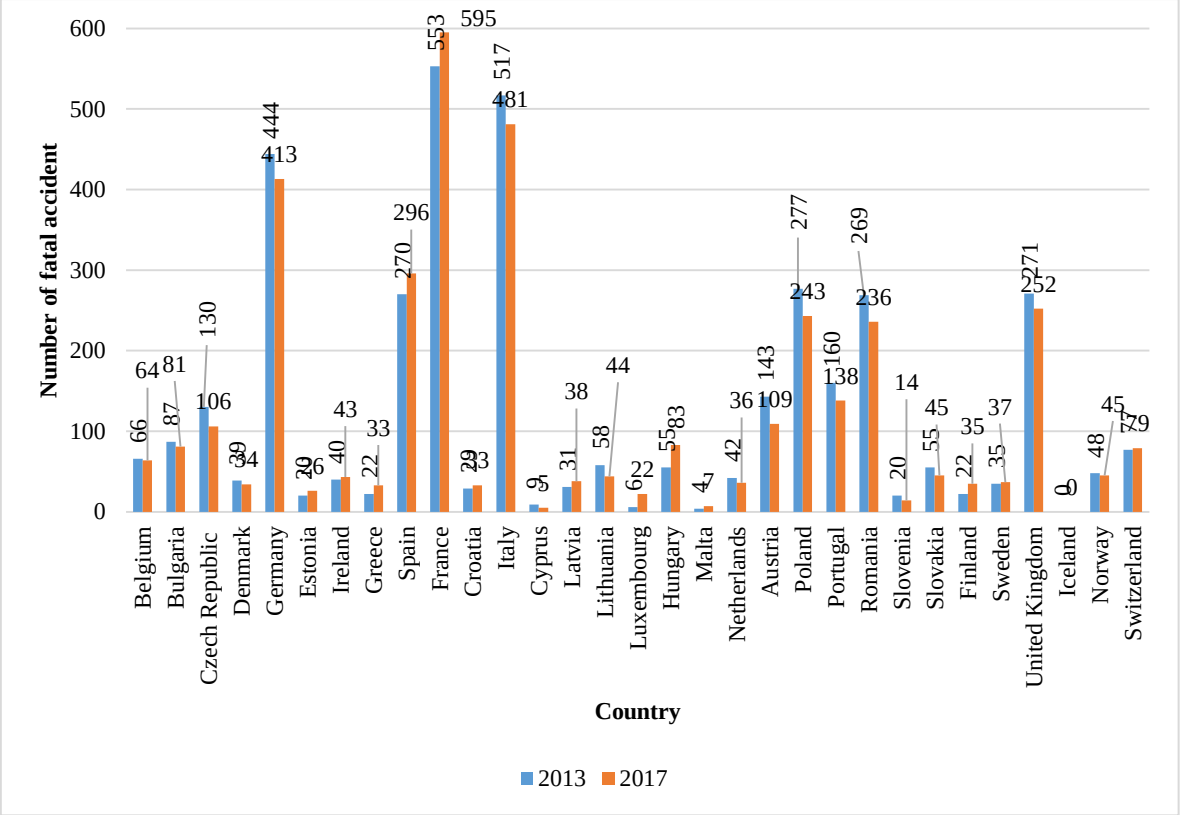


Figure 1.63. Distribution of fatal accidents for EU member states during 2013–2017
Source: European Statistics on Accidents at Work, 2018

From the perspective of the fields of activity where these non-fatal accidents had occurred, the main sectors of activity considered for evaluation were agriculture; industry and construction (except mining); services of the business economy; agriculture, forestry, and fishing; crop and animal production; hunting and related service activities; and forestry and logging. It can be seen, Figure 1.64, that agriculture, industry and construction (except mining), and services of the business economy record the most work accidents. The level reached during the analysis period was over 2.4 million accidents. The lowest number of work accidents was recorded in forestry and logging (Hadjimanolis, 2015)

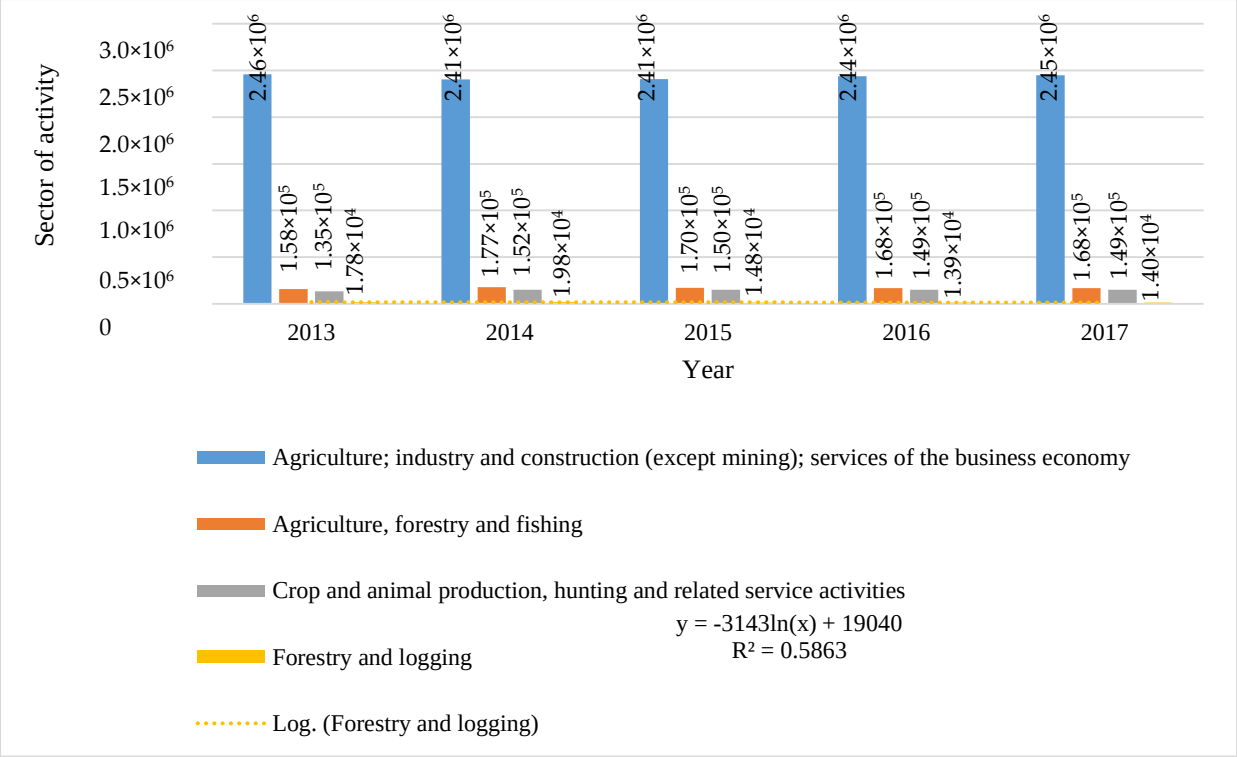


Figure 1.64. The distribution of non-fatal work accidents on the main fields of activity for the EU member states during 2013–2017

Source: European Statistics on Accidents at Work, 2018

In the EU-28, an incidence rate of 1,533.39 was recorded in 2013, and in the year 2015 there was an average of 1513 non-legitimate accidents per 100,000 people (see Figure 1.65). The incidence rate among EU member states was less than 100 accidents per 100,000 people employed in Bulgaria and Romania and over 2750 per 100,000 people employed in Spain, Portugal, and France. The highest rate was recorded in France, reaching a level of 3160 non-fatal accidents per 100,000 people employed.

The incidence rate for non-fatal accidents increased in 2016 and 2017 because, among others, agriculture, industry and construction (except mining), and services of the business economy domain presented an increase of over 30,000 non-fatal accidents in 2016 compared to 2015 (see Figure 1.64)

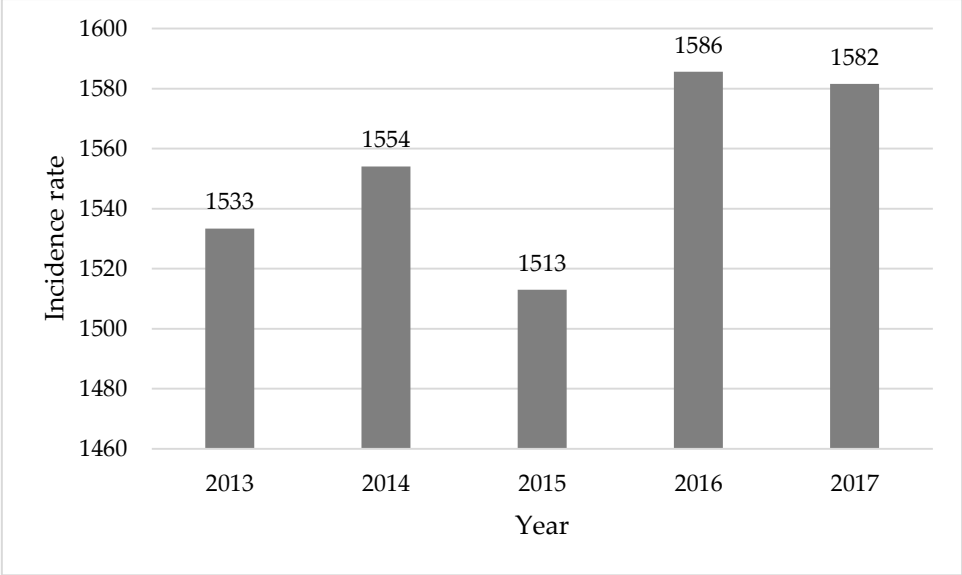


Figure 1.65. Incidence rate for non-fatal accidents
Source: European Statistics on Accidents at Work, 2018

According to the European Commission, the explanation for non-fatal accident rates would be that current reporting systems do not support victims in reporting accidents (National Institute of Statistics—Romania, 2018). This is why many times these accidents remain undeclared and are not found in national and international statistics. It can be seen that the incidence rate is between 1.7 and 1.83. The lowest level was recorded in 2017, or 1.71 deaths per 100,000 employees, Figure 1.66.

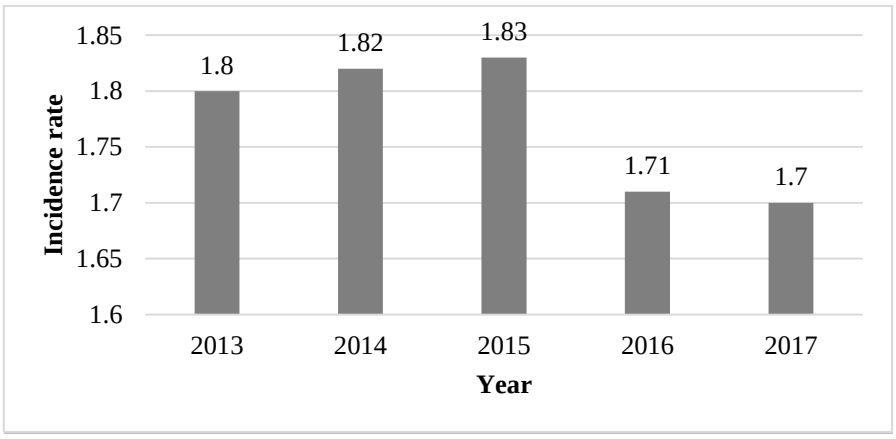


Figure 1.66. Incidence rate for fatal accidents
Source: European Statistics on Accidents at Work, 2018

Assessing the overall situation of OSH, it can be seen that the number of accidents at work varied greatly depending on the economic activity in question. Men-dominated activities generated more work-related accidents because they were more risk-intensive sectors (construction, machine-building, and others) (National Institute of Statistics—Romania, 2018). In the EU-28, the construction, production, transport and storage sectors and agriculture, forestry, and fishing accounted for only two-thirds (67.8%) of the total fatal accidents at work and less than half (44.9%) of total fatal accidents at work, respectively, in 2015. More than one in six (16.0%) fatal accidents at work in the EU-28 in 2017 occurred in the construction sector,

and the manufacturing sector had a share of 15.0% followed closely by transport and storage (15.5%). Agriculture, forestry, and fishing (13.2%) were also registered as an important share (European Statistics on Accidents at Work, 2018). Outside the transport and storage domains, all other service activities recorded relatively lower rates of total fatal accidents. However, non-fatal accidents have always been present in wholesale and retail trade (13.6% of total EU-28 in 2017), human health and social work activities (10.5%), and public administration and defense (5.63%) (European Statistics on Accidents at Work, 2018).

In European Union, the situation of work accidents can be summarized by a series of statements:

- Starting in 2013, approximately 3500 workers annually lose their lives in work accidents.
- More than 3,000,000 work accidents occur annually in the EU, involving an absence of more than three days from work.
- More than 24% of employees believe their health is threatened as a result of the work done.
- Of the existing employees in the EU, over 25% say their work has a negative effect on health.
- As a result of the accident rate, the costs of medical leave are disproportionately high. In Germany, medical leave is totaling 460 million days annually.
- Social insurance leads to high costs that is the social insurance that can be attributed to illness or accidents. In some EU member states, costs are rising.

To improve the situation of accidents at work in the EU, emphasis is placed on improving and revitalizing the member states' results of implementing health and safety policies; enhancing the capacity of micro and small enterprises to implement effective and efficient risk prevention measures; increasing prevention of occupational diseases by combating existing and new emerging risks; and assessing changes in country (European Statistics on Accidents at Work, 2018)

The situation of work accidents in Romania

The number of employees in Romania in 2017 according to the national statistics is shown in Figure 1.67. In 2013, there were 5,076,512 employees with 24% less than the level reached in 2017. Since 2014, the number of employees has been increasing. Hence, the idea of increased number of accidents can be supported (National Institute of Statistics—Romania, 2018).

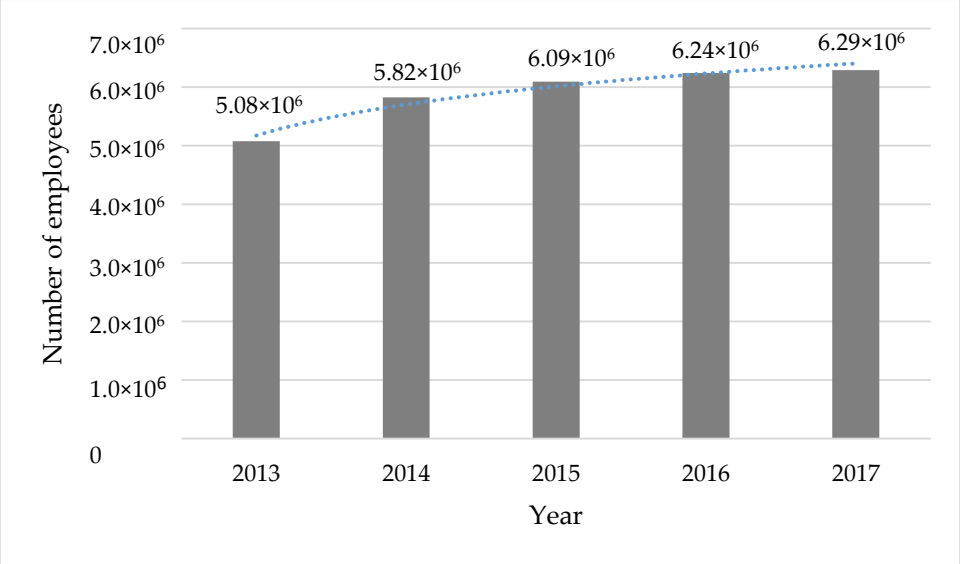


Figure 1.67. Number of employees in Romania in 2013–2017

Source: National Institute of Statistics—Romania, 2018

Assessing the situation of the EU member states, it can be noticed that the dynamics of Romania's variation for the year 2017, compared to 2013, from the perspective of non-fatal accidents was + 21.29%, and the dynamics of the variation for fatal accidents was −12.27%. It can be said that the situation is acceptable, considering the global situation for EU and national economy.

From the perspective of the number of non-fatal accidents at work, Figure 1.68, it can be seen that at the national level, the lowest number was registered in 2013, i.e., 3627 accidents. Starting with 2015, the number of non-fatal accidents is on the rise, with an increase of 11.70% in 2017 compared to 2015.

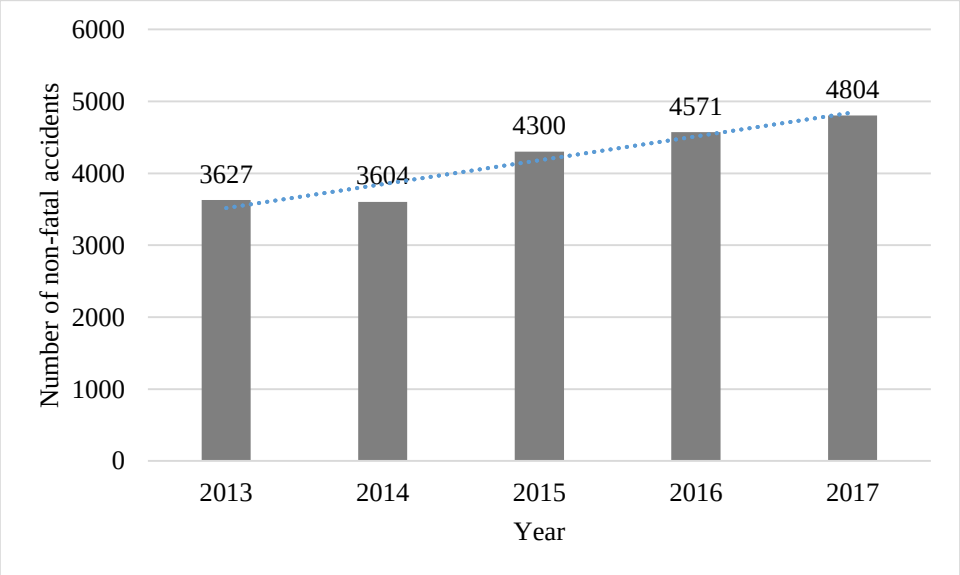


Figure 1.68. The situation of non-fatal accidents in Romania during 2013–2017
Source: National Institute of Statistics—Romania, 2018

The non-fatal accident frequency index, Figure 1.69, had the lowest level in 2013, with 0.76 non-fatal accidents per 1000 employees in Romania. The value of this index was rising, reaching the highest level in 2017, i.e., 0.93‰. The percentage increase registered in 2017 was 22.30% compared to 2013.

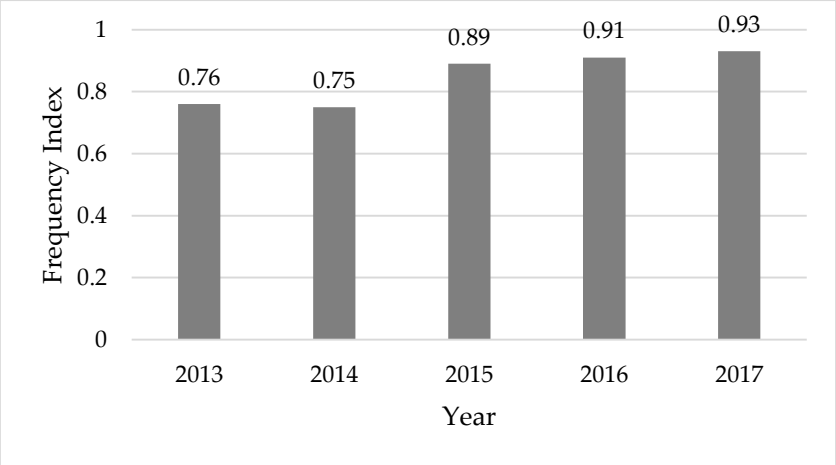


Figure 1.69. Frequency index of non-fatal accidents in Romania during 2013–2017
Source: National Institute of Statistics—Romania, 2018

Fatal accidents have a downward trend, Figure 1.70, with the highest level being recorded in 2013 when 199 fatal accidents occurred. The lowest level was recorded in 2016, with 163 fatal accidents. This situation of fatal accidents, as also stated for EU, highlights the situation of accidents declared by employers.

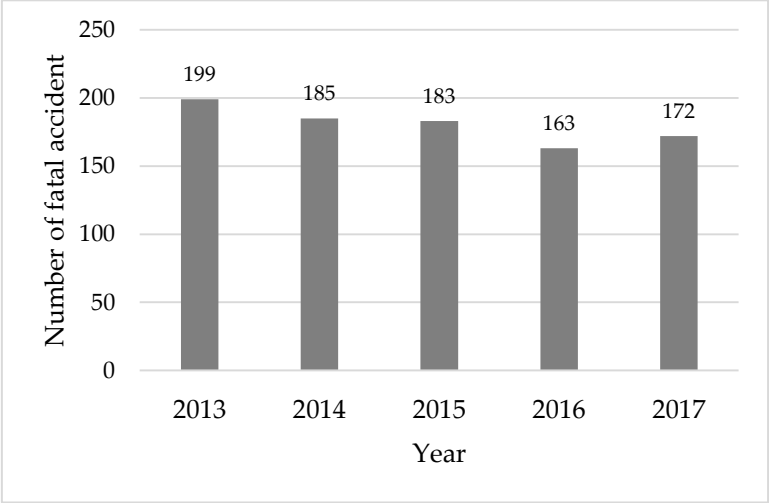


Figure 1.70. Situation of fatal accidents in Romania during 2013–2017
Source: National Institute of Statistics—Romania, 2018

The fatal accidents frequency index, Figure 1.71, has a value of about 0.04 per 1000 employees in Romania. This level is maintained, approximately, throughout the analysis period. Starting with 2016, the frequency index value reached 0.03 per 1000 employees.

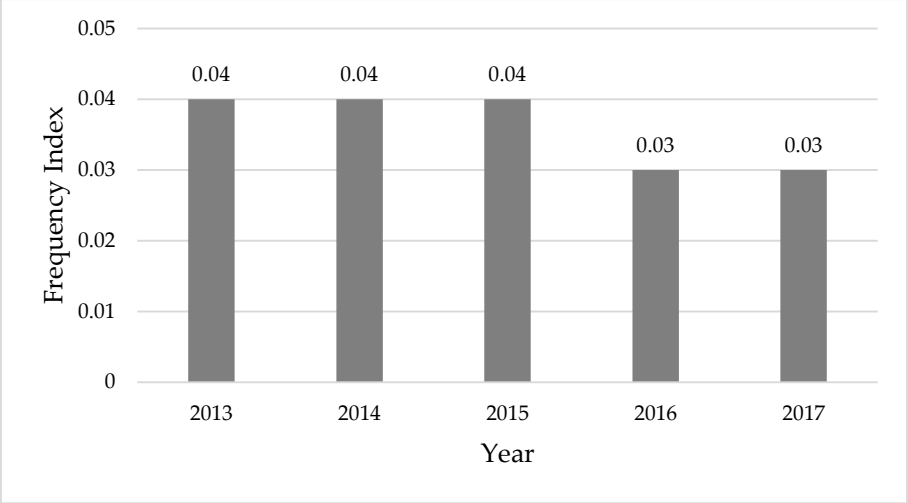


Figure 1.71. The frequency index of fatal accidents in Romania during 2013–2017

Source: National Institute of Statistics—Romania, 2018

To identify the sectors of activity that generate the most fatal and non-fatal work accidents, the following were considered—building construction, retail, except motor vehicles and motorcycles; land transport and pipeline transport; manufacture of motor vehicles, trailers and semi-trailers; woodworking and manufacture of wood and cork products, except furniture; food industry; wholesale trade, excluding trade in motor vehicles and motorcycles; and the metal and metal products industry, excluding machinery, equipment, and installations. The situation of work accidents by sectors of activity is presented in Figure 1.72. The field of activity of retail trade, except for motor vehicles and motorcycles, recorded the most accidents during the entire period of analysis. This field is followed by land and pipeline transport and building construction. The highest number of accidents in 2013 was achieved in the building sector, and the lowest in the metal and metal products industry, excluding machinery, equipment, and installations. At the level of 2017, most non-fatal accidents occurred in the retail trade, except for motor vehicles and motorcycles, and the lowest in the metal and metal products industry, excluding machinery, equipment, and installations. In 2017, the number of non-fatal accidents decreased particularly in the fields of building construction; woodworking and manufacture of wood and cork products, except furniture; and retail except motor vehicles and motorcycles. Information campaigns on health and safety at work, as well as checks at companies to combat illegal work (undeclared work), were intensified in 2017. The causes of work accidents were the non-observance of the labor protection instructions, inappropriate maneuvers with ignoring the risk situation and lack of use of protective equipment (The Minister of Labour and Social Justice, 2018).

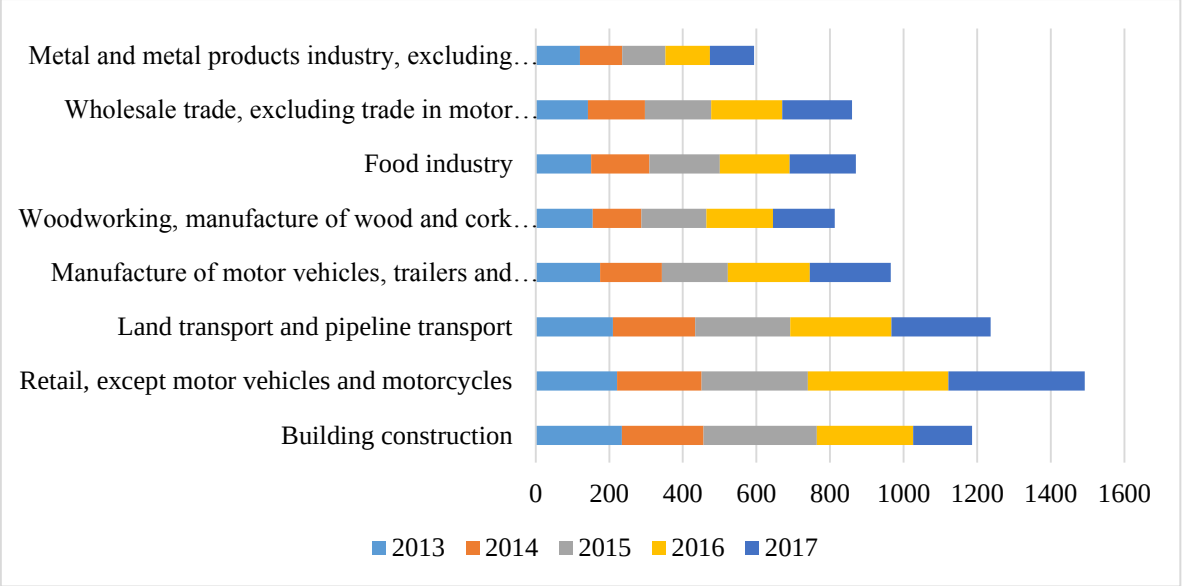


Figure 1.72. Number of non-fatal accidents in Romania during 2013–2017
Source: European Statistics on Accidents at Work, 2018

From the perspective of fatal accidents, Figure 1.73, the building sector had the highest number of work accidents. Death rates for this industry fell between 18 and 20 fatal accidents per year per 1000 employees. For 2013, most fatal accidents were registered in the field of building activity, and the lowest in the food industry. In 2017, most accidents were recorded in the building sector and the lowest level was recorded in the wood processing and food industry. The number of fatal work accidents began to decline in most areas in 2017 due to the intensification of information campaigns on health and safety at work, as well as checks on societies to combat black work (The Minister of Labour and Social Justice, 2018).

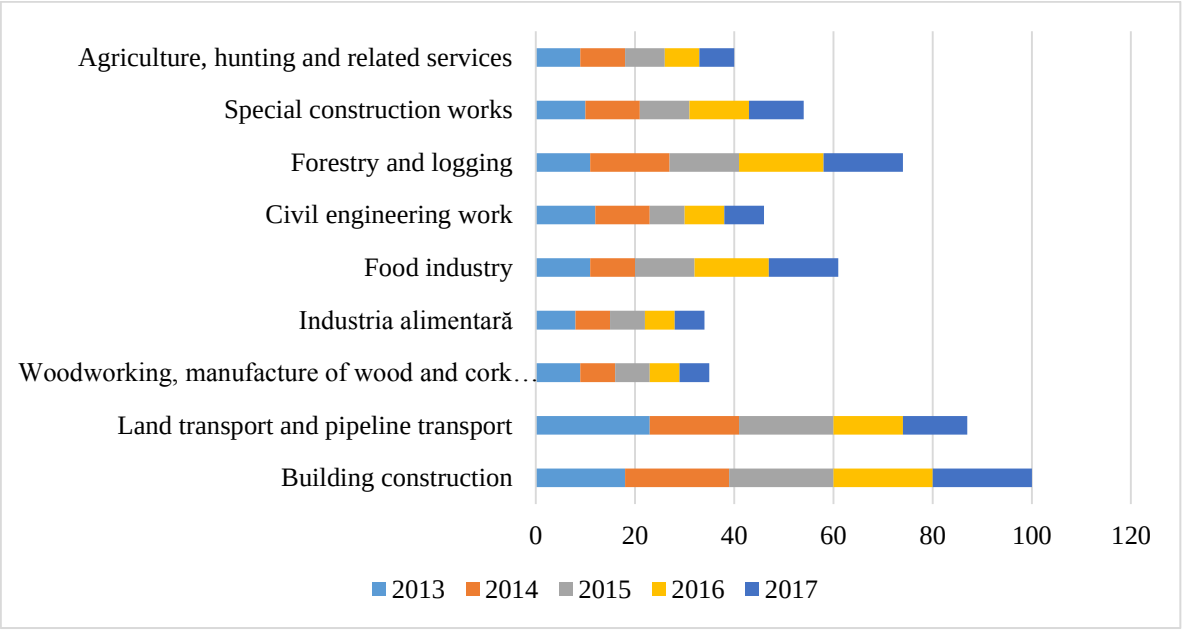


Figure 1.73. Number of fatal accidents in Romania during 2013–2017
Source: European Statistics on Accidents at Work, 2018

In order to identify the age groups involved in the work accidents, an evaluation is made of the following groups: <17; > 60 years; 17–20 years; 20–30 years; 30–40 years; 40–50 years; and 50–60 years, Figure 1.74. Most accidents were recorded in the 40–50 age group, followed by the 50–60 age group. By applying prevention methods and actions at national level, the age group of 30–40 years and 20–30 years experienced a decrease in the number of accidents in the period 2016–2017 compared to the period 2013–2015. The lowest level of accidents was recorded in the age group of 17–20 years.

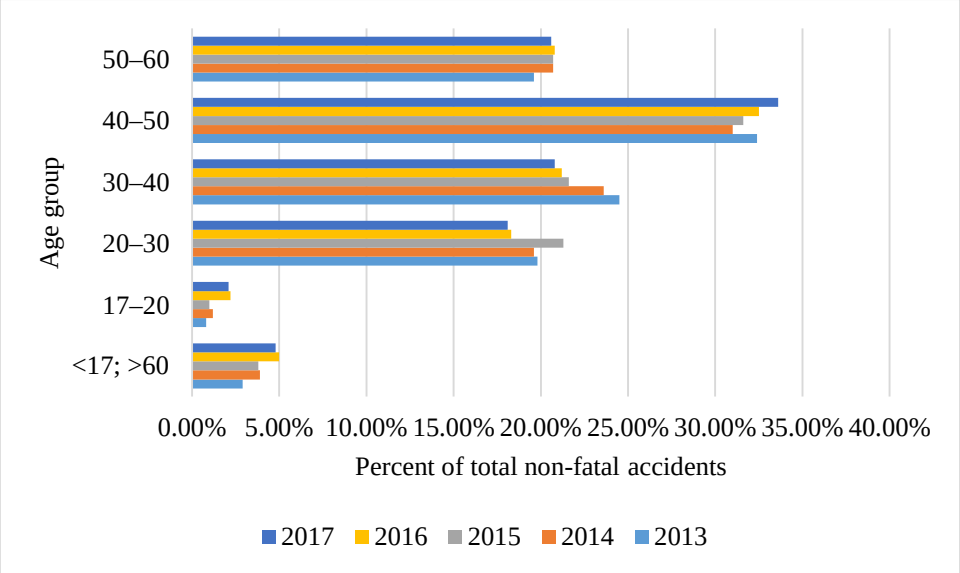


Figure 1.74. Assessment of non-fatal work accidents by age group
Source: European Statistics on Accidents at Work, 2018

By assessing fatal accidents by age group, it can be noticed that the same situation of non-fatal accidents was also found in fatal accidents, Figure 1.75. Most accidents were recorded in the 40–50 age group, followed by the 50–60 age group. The lowest level of accidents was recorded in the age group of 17–20 years. Age groups 30–40 and 20–30 showed fewer fatalities than non-fatal.

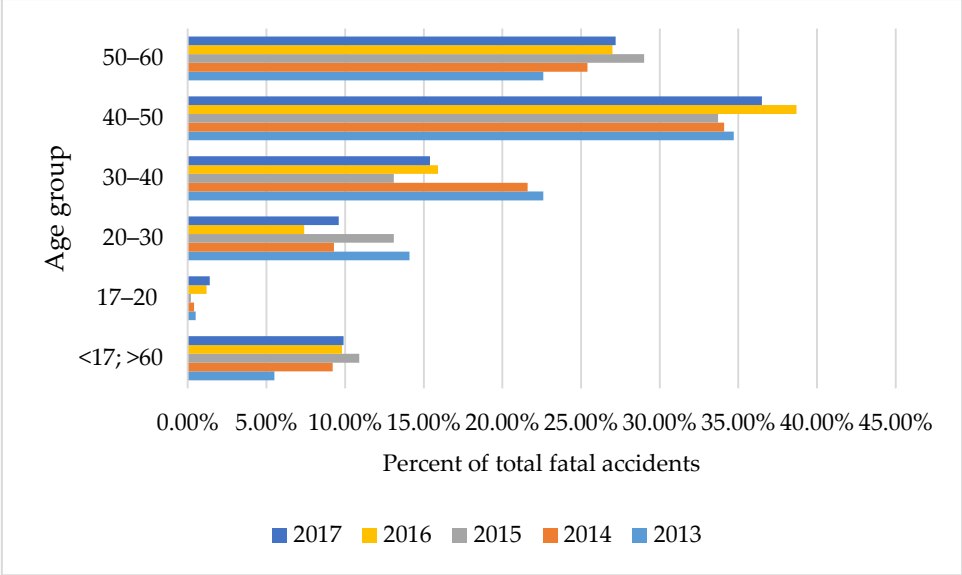
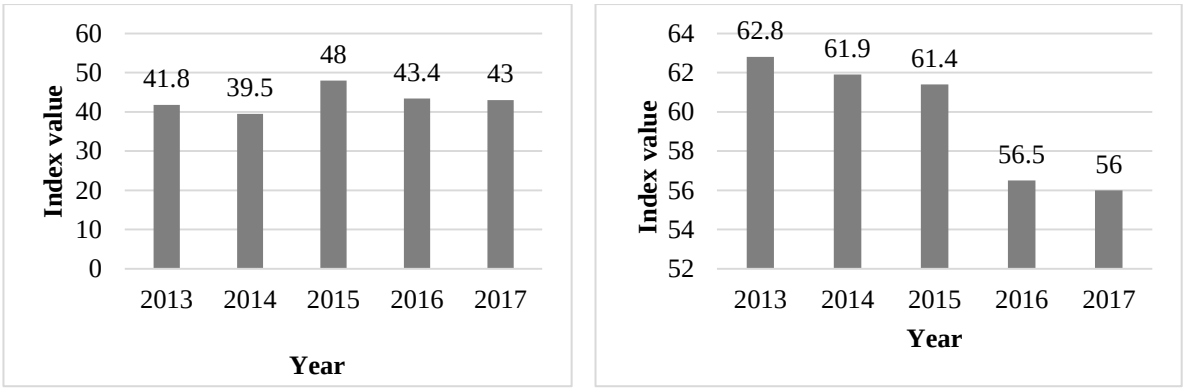


Figure 1.75. Assessing fatal work accidents by age group
Source: European Statistics on Accidents at Work, 2018

The above-mentioned accident situation involved a number of injury costs falling into the following categories (Bellamy, et al., 2010; Masi et al., 2015; Hadjimanolis et al., 2015; Cagno, et al., 2016; Bonafede, et al., 2016; Cunningham, et al., 2015):

- Productivity costs: costs related to falling production or productivity that may affect organizational competitiveness;
- Healthcare costs: direct medical costs and indirect medical costs;
- Loss of the employee's quality of life: the financial assessment of the decrease in the quality of life, such as due to pain and suffering;
- Administration costs: administration costs related to the application for certain facilities or for the reporting of an accident at the workplace;
- Insurance costs: compensation payments and insurance premiums.

These cost categories can be assessed on the basis of stakeholders—employees and family, employers, national government, and society. Indicators that highlighted organizational costs for fatal or non-fatal accidents include the severity index and the average duration index. The severity index, Figure 1.76 (a), recorded the most days of work incapacity, reported per 1000 employees, in 2015, i.e., 48 ‰. Starting with 2015, the number of days of incapacity began to decrease. From the perspective of the average duration index, the number of days lost on average by an injured person can be seen in Figure 1.76 (b), and that the duration was decreasing from 2013 onward. The lowest level was registered in 2017, e.g., 56 per 1000 employees.



(**a**) (**b**)

Figure 1.76. The indicator values: (a) The severity index, Ig and (b) average duration index for the 2013 period in Romania

Source: National Institute of Statistics—Romania, 2018

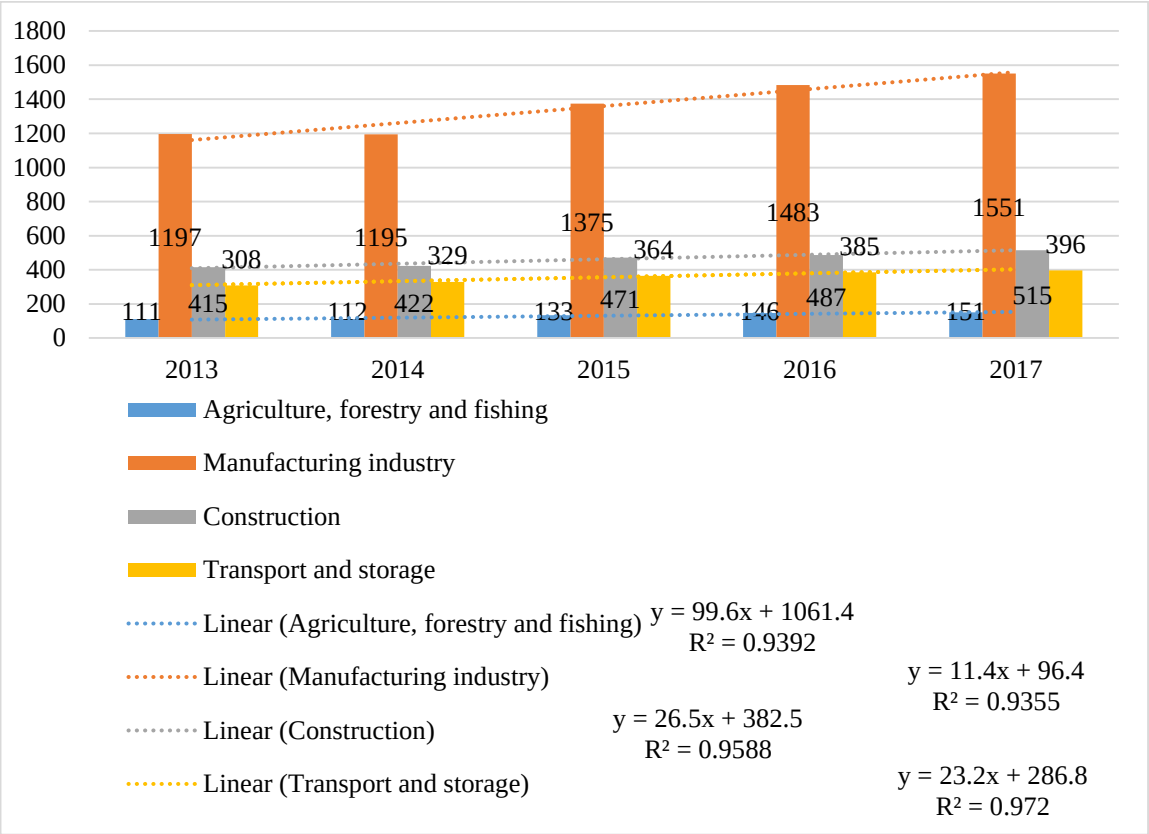
Trends of work accidents in Romania and Bulgaria

Assessing the situation of the EU member states, I selected an EU member country to make a series of comparisons regarding work accidents. This section also includes a series of predictions of accidents situations for the 2018–2020 period. In order to achieve this assessment between the two EU member states, Romania and Bulgaria, we have selected four fields of activity: agriculture, forestry, and fishing;, manufacturing industry; construction; and transport and storage. These areas of activity have been selected because for the EU (Figure 4), agriculture and construction were among the domains with the most accidents; for these domains, Romania registered the most accidents for the 2013–2017 period, and they were also among the areas with the most accidents in Bulgaria (Eurostat European Commission, 2018; Pedro et al., 2012; Wu et al., 2018; Hämäläinen et al., 2017). The cases of accidents for the period 2013–2017 are presented taking into account the employee's gender and age.

Assessing the current situation for the EU, the situation of Romania is compared with that of Bulgaria. Both Romania and Bulgaria are EU member states. Bulgaria has 7,054,034 inhabitants, 73.5% is the employability rate, 5% unemployment rate, 100.4% industrial production rate, 3.1% GDP growth, 99.3% total producer price index, and 98.8% construction production index (Pedro, and Swuste, 2012). In 2018, Romania had 19.5 million inhabitants, with 4.2% GDP growth, 3.3% unemployment rate, 83% employment rate, increasing industrial production rate, and 99.6% construction production index (Eurostat European Commission, 2019).

The situation of work-related accidents for Romania (Figure 1.77a) and Bulgaria (Figure 1.77b) highlights the fact that the manufacturing industry is registering the most work accidents. The number of accidents in the manufacturing industry in 2017 increased by 23% compared to 2013. Since 2013, the number of accidents has increased in this area as a result of the development of the Romanian industry (a number of multinational companies have entered the Romanian market). The number of accidents for agriculture, forestry, and fishing did not increase significantly due to the fact that this sector was not very developed in Romania, and there was not much business support in this field (Work Inspection, 2018; Sgourou et al., 2010).

The construction sector had grown in large cities in Romania as a result of the residential sector demand. The increase in the number of accidents in 2017 is about 20% compared to 2013. Legislative measures need to be improved in this area. The number of accidents in the field transport and storage grew by about 20% in 2017 compared to 2013 due to the increase in activity in the industry, and also due to a lack of highways and adequate infrastructure. At the end of 2018, Romania had approximately 806 kilometers of highway (Cioca, and Ivascu, 2018).



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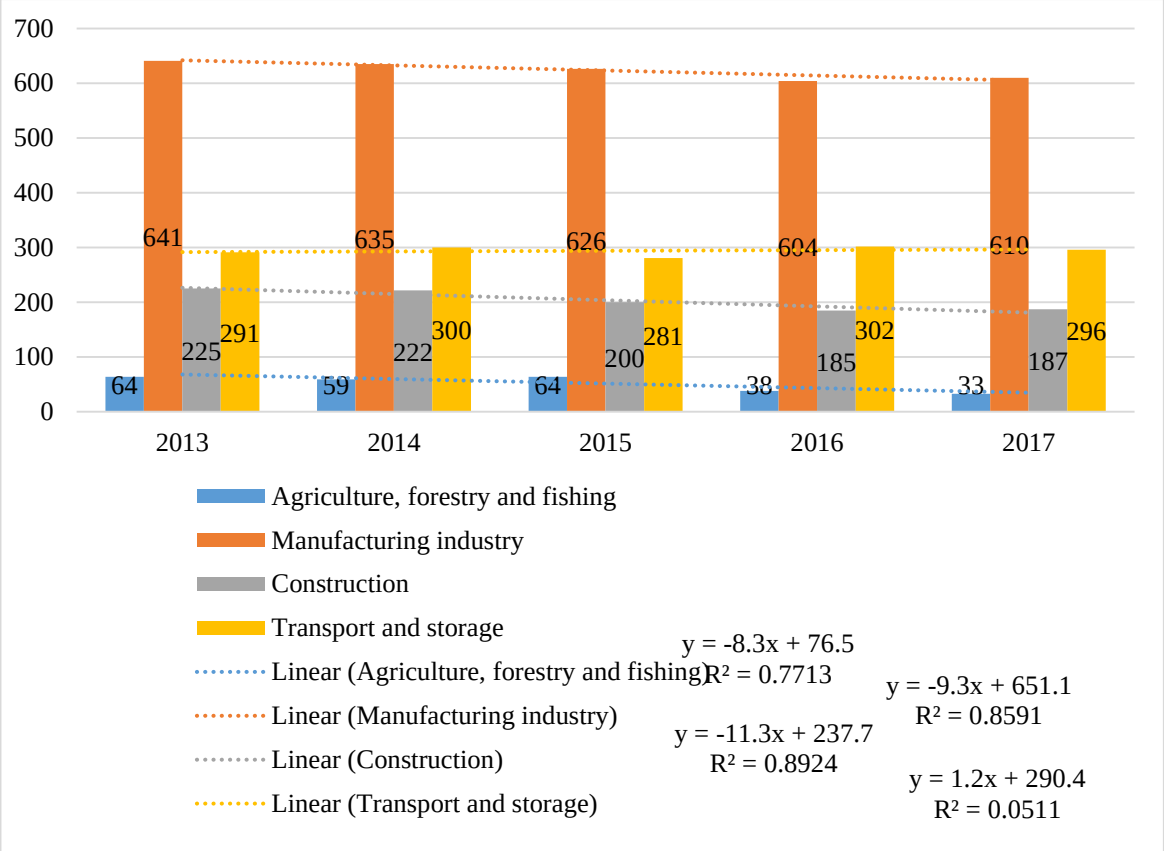


(**b**)

Figure 1.77. Situation of accidents in Romania (a) and Bulgaria (b) in the fields of: agriculture, forestry, and fishing; manufacturing industry; construction; and transport and storage in the period 2013–2017.

Assessing the situation in Bulgaria, Figure 1.77 (b), it can be observed that the manufacturing sector is the one that records the most accidents due to the industrialization of some areas in the country (Pedro et al., 2012). The number of accidents in 2013 was 641, 5% higher than in 2017. The number of accidents decreased as a result of the national legislation being updated (Eurostat European Commission, 2019). The agricultural sector had the least number of accidents because this sector was not very developed. The construction sector showed a decrease in the number of accidents, reaching 187 in 2017. The transport and storage sector maintained the number of accidents at 290–300 for the analyzed period.

From the perspective of the gender of the employees injured in these sectors, the male gender predominated in Romania, Table 1.48. In the manufacturing industry, there was a 30% share of women, and in the rest of the domains, the number of accidents was mainly registered for the male gender.

Table 1.48. The distribution of accidents in Romania by gender

Year	**2013**		**2014**		**2015**		**2016**		**2017**	
Domain/gender	M	F	M	F	M	F	M	F	M	F
Agriculture, forestry, and fishing	105	6	105	7	124	9	131	15	140	11
Manufacturing industry	914	283	924	271	1070	305	1099	384	1156	395
Construction	409	6	415	7	459	12	472	15	498	17

Transport and storage	270	38	281	48	329	35	335	50	345	51

Source: Eurostat European Commission, 2018

Assessing the situation of Bulgaria, Table 1.49, one can notice the same trend as in Romania. The manufacturing industry sector recorded the most accidents, and one-third of them was registered for women. The next sector in which women were injured was the transport and storage sector, as in the case of Romania.

Table 1.49. The distribution of accidents in Bulgaria by gender

Year	**2013**		**2014**		**2015**		**2016**		**2017**	
Domain/gender	M	F	M	F	M	F	M	F	M	F
Agriculture, forestry and fishing	59	5	5	4	57	7	36	2	31	2
Manufacturing industry	460	181	181	183	485	141	417	187	420	190
Construction	220	5	5	6	198	2	178	7	181	6
Transport and storage	235	56	56	66	207	74	218	84	215	81

Source: Eurostat European Commission, 2018

From the perspective of the age category, for evaluation there were considered—less than 25 years, from 25 to 54 years, and 55 years or over, Table 1.50. These categories were considered because the series of data provided in the European Commission database were thus defined. The category "25 to 54 years" has the most accidents, being followed by the "55 years or over" category. According to (Eurostat European Commission, 2018), most injured workers and workers fell in the category from 25 to 54 years. This fact was also confirmed in Romania (Eurostat European Commission, 2018).

Table 1.50. The distribution of accidents in Romania by age

Category	**less than 25 years**					**from 25 to 54 years**					**55 years or over**				
Domain/Year	2013	2014	2015	2016	2017	2013	2014	2015	2016	2017	2013	2014	2015	2016	2017
Agriculture, forestry, and fishing	3	4	11	5	6	99	98	101	117	121	9	10	21	24	24
Manufacturing industry	130	132	169	173	170	920	921	1033	1100	1159	147	142	173	210	222
Construction	29	30	32	32	32	319	324	367	342	358	67	68	72	113	125
Transport and storage	15	17	20	23	24	248	254	292	297	299	45	58	52	65	73

Source: Eurostat European Commission, 2018

The injured workers' age perspective in Bulgaria, Table 1.51, shows that the situation is the same as in Romania. The category "25 to 54 years" has the most accidents, being followed by the "55 years or over" category (Source: Eurostat European Commission, 2018).

Table 1.51. The distribution of accidents in Bulgaria by age

Category	**less than 25 years**					**from 25 to 54 years**					**55 years or over**				
Domain/Year	2013	2014	2015	2016	2017	2013	2014	2015	2016	2017	2013	2014	2015	2016	2017
Agriculture, forestry, and fishing	10	5	5	1	1	42	41	44	28	29	12	13	15	9	3
Manufacturing industry	40	64	67	69	60	480	460	452	424	440	121	111	107	111	110
Construction	10	12	10	9	10	160	159	140	133	130	55	51	50	43	47
Transport and storage	6	6	5	9	8	240	235	208	201	202	45	59	68	92	86

Summary of findings

The following can be systematized from the evaluations:

(A) For EU:

- From the perspective of non-fatal work accidents, starting with 2016, their number has begun to increase as a result of overcoming economic instability and improving business activities.
- The largest number of accidents is registered in Germany, France, Spain, and Italy due to the economic level of each country and the level of industrialization.
- The phenomenon of low rates of non-fatal incidence can be considered as reflecting under-reporting, assuming that many accidents remain unreported. The incidence rate of fatal accidents is different, as it is much more difficult to avoid fatal accidents.
- The fatal accident situation has been decreasing since 2015.
- Industry development will lead to increased labor accidents, so prevention and control methods need to be supported at country level.
- Developed countries, as a result of intense industrial activity, have a high rate of non-fatal accidents.
- The industry sector has the most work accidents.
- The rising rate of non-fatal accidents leads to an increase in incidence rate.

Assessing the existing situation in the EU, it is noticed that Romania and Bulgaria are member states that can be compared from the perspective of work accidents [European Statistics on Accidents at Work, 2018,21–28].

(B) For Romania:

A T-test and ANOVA analysis were conducted to compare the significant association with each category for frequency index of non-fatal accidents and frequency index of fatal accidents. The following were considered:

i. Data were classified into two categories—non-fatal accidents and fatal accidents.

ii. The selected variables for this study were (1) sex and (2) age.

iii. Two indicators were calculated—the labor accident rate index (accidents per 1000 employees) and the frequency accident rate index for fatal accidents.

iv. Significant differences between sex groups were statistically compared using T-tests. The other groups were compared using ANOVA tests and were further compared between individual categories. P values below 0.05 were considered statistically significant.

v. Two hypotheses were formulated (hypothesis (H0)—non-fatal work-related accidents did not present differences between age groups, and (H1)—at least two age categories showed differences for non-fatal work-related accidents).

The results are shown in Table 1.52 and Table 1.53. There was a significant difference in the frequency index of non-fatal on gender at $p < 0.001$ level. The value of male workers (mean = 0.748, SD = 0.076) was much higher than female workers' (mean = 0.338, SD = 0.038). Age categories 30–40 (mean = 0.836, SD = 0.091), 40–50 (mean = 1.162, SD = 0.208), and 50–60 (mean = 1.062, SD = 0.138) showed higher levels of workplace accidents. As a result of the

value of p, the null hypothesis was invalidated, and the hypothesis according to which there were differences in the number of accidents by age classes was confirmed.

Table 1.52. Result of ANOVA analysis (frequency index of non-fatal).

Category		Mean (SD)	Year				
			2013	2014	2015	2016	2017
Gender (t = 16.125, p < 0.001)							
(1)	Male	0.748 (0.076)	–	–	–	–	–
(2)	Female	0.338 (0.038)					
Age (F = 175.206, p < 0.001)							
<17; >60		0.116 (0.011)	–	+	+	+	+
17–20		0.194 (0.019)	+	–	+	+	+
20–30		0.606 (0.076	+	+	–	*	*
30–40		0.836 (0.091)	+	+	+	–	*
40–50		1.162 ± 0.208	+	*	+	+	–
50–60		1.063 ± 0.138	+	+	*	*	+

+ Indicates a significant difference, p-value < 0.05; * Indicates a significant difference, p-value < 0.001.

Following the same steps, the two hypotheses are considered—(H0), fatal accidents do not show differences between age groups and (H1), at least two age categories show differences for fatal work accidents. By comparing the results obtained, it was observed that working women (mean = 2.738, SD = 1.014) recorded one-third of men's fatal injuries (mean = 8.548, SD = 2,023). It was noticed that for the 40–50 category (mean = 2.408, SD = 1.454), the most fatalities were recorded, followed by the 50–60 category (mean = 1.748, SD = 0.890). As a result of the value of p, the null hypothesis was invalidated, and the hypothesis according to which there were differences in the number of accidents by age classes was confirmed.

Table 1.53. Result of ANOVA analysis (frequency index of fatal).

Category		Mean (SD)	Year				
			2013	2014	2015	2016	2017
Gender (t = 10.144, p < 0.001)							
(3)	Male	8.548 (2.023)	–	–	–	–	–
(4)	Female	2.738 (1.014)					
Age (F = 175.206, p < 0.001)							
<17; >60		0.670 (0.211)	–	+	+	*	+
17–20		0.164 (0.039)	*	–	+	+	+
20–30		0.606 (0.076	+	*	–	+	+
30–40		0.920 (0.791)	+	+	+	–	+
40–50		2.408 (1.454)	+	*	+	+	–
50–60		1.748 (0.890)	+	+	+	*	*

+ Indicates a significant difference, p-value < 0.05; * Indicates a significant difference, p-value < 0.001.

- Employee maturity increased the accident rate.
- As a result of the statistical analysis, it could be noticed that for Romania, the 40–50 and 50–60 age groups were the most vulnerable to work accidents. A cause [2,3] of these accidents would be shortcomings in the organization of work activities. They accounted for about 30% of work accidents. Other causes were work-related stress (28%) and prolonged work or excessive workload (20%) [3].
- The transport sector recorded a high level of accidents at work due to the fact that the infrastructure in Romania was not very good. (The length of the road network in Romania is 198,589 km, out of which 806 km constitute highways and 15,934 km national roads.)

- The number of work accidents was increasing during the 2013–2017 analysis period as a result of the increase in the number of employees and the development of the business environment. In 2017, there was an increase of approximately 24% in the number of employees compared to 2013.
- In 2017, most non-fatal accidents occurred in the retail trade, except for motor vehicles and motorcycles. This is supported by the fact that, at national level, the number of entrepreneurs in this field is increasing in recent years.
- Since 2016, work accidents have started to increase, reaching 3,315,101 in 2017.
- The number of employees was increasing in the period 2013–2017, the number of non-fatal accidents was decreasing in the period 2014–2017, and the frequency index for 2014–2017 was decreasing (except for 2015). This highlights the fact that the actions taken to reduce accidents did not show the expected efficiency.
- The number of employees was increasing during the period 2013–2017, the number of fatal accidents decreased in the period 2014–2017, and the frequency indexes for the period 2014–2017 was decreasing (the exception being 2015). This underlines that actions taken to reduce fatal accidents have had a positive impact or fatal accidents have not been declared by businesses.
- In some areas of activity, e.g., retail, except for motor vehicles and motorcycles, the accident rate was increased requiring prevention and control actions.
- Land transport reported a considerable (28%) fatal accident rate in 2013–2017.

(C) For Romania and Bulgaria:

- For the areas of activity analyzed—agriculture, forestry, and fishing; manufacturing; construction; and transport and storage—Romania and Bulgaria, the comparable countries from the economic perspective, showed the most accidents in the manufacturing industry sector.
- For the domains assessed, the regression analysis led us to the following trends in Romania and Bulgaria. The closer the R2 value to 1, the better the fit.
- For the agricultural, forestry, and fishing sector, for Romania, R-squared of 0.9355 means that 94% of the variance in the data is explained by the line and 6% of the variance is due to unexplained effects. If the level of development of this sector is maintained and the competent institutions do not develop new procedures, the trend of accidents at work is rising, reaching 184 accidents in 2020 (Table 1.54).
- For the manufacturing industry, R-squared of 0.9392 means that 94% of the variance in the data is explained by the line and 6% of the variance is due to unexplained effects. The number of accidents for the forecast period 2018–2020 is on the rise, reaching 1857 accidents in 2020.
- For the construction sector, R-squared of 0.9588 means that 96% of the variance in the data is explained by the line, and 4% of the variance is due to unexplained effects. The number of accidents will increase, reaching 594 in 2020.
- For the transport and storage sector, R-squared of 0.972 means that 97% of the variance in the data is explained by the line and 3% of the variance is due to unexplained effects.

Accidents in this area of activity will be increased, as the situation in the country is not improving with regards to infrastructure and legislative procedures. In 2020, there will be 472 accidents.

Table 1.54. Trends of accident at work for period 2018–2020 in Romania.

Domain	Regression analysis/R-square	2018	2019	2020
Agriculture, forestry, and fishing	$y = 11.4x + 96.4$ $R^2 = 0.9355$	165	176	184
Manufacturing industry	$y = 99.6x + 1061.4$ $R^2 = 0.9392$	1660	1758	1857
Construction	$y = 26.5x + 382.5$ $R^2 = 0.9588$	541	568	594
Transport and storage	$y = 23.2x + 286.8$ $R^2 = 0.972$	426	449	472

- For the agricultural, forestry, and fishing sector, for Bulgaria (Table 1.55), R-squared of 0.7713 means that 78% of the variance in the data is explained by the line and 22% of the variance is due to unexplained effects. The trend of the number of accidents is decreasing, as shown in Table 8.
- For the manufacturing industry, R-squared of 0.8591 means that 86% of the variance in the data is explained by the line and 14% of the variance is due to unexplained effects. The number of accidents for the projection period 2018–2020 is decreasing, reaching 575 accidents in 2020.
- For the construction sector, R-squared of 0.8591 means that 86% of the variance in the data is explained by the line and 14% of the variance is due to unexplained effects. The number of accidents will drop, reaching 149 in 2020.
- For the transport and storage sector, R-squared of 0.0511 means that 5% of the variance in the data is explained by the line and 95% of the variance is due to unexplained effects. Accidents in this area of activity will amount to 300 in 2020.

Table 1.55. Trends of accident at work for period 2018–2020 in Bulgaria.

Domain	Regression analysis/R-square	2018	2019	2020
Agriculture, forestry, and fishing	$y = -8.3x + 76.5$ $R^2 = 0.7713$	27	24	18
Manufacturing industry	$y = -9.3x + 651.1$ $R^2 = 0.8591$	595	585	575
Construction	$y = -11.3x + 237.7$ $R^2 = 0.8924$	170	159	149
Transport and storage	$y = 1.2x + 290.4$ $R^2 = 0.0511$	297	298	300

- Assessing Romania and Bulgaria, it can be noticed that in Romania the number of accidents is increasing, while in Bulgaria, except for transport and storage, the number of accidents is decreasing.

Discussion and model proposed for the prevention and control of work accidents

Taking into account the EU actions to reduce the number of accidents, the *EU Strategic Framework on Health and Safety at Work 2014–2020* and the *National Occupational Safety and Health Strategy for the 2017–2020* periods are further assessed. Analyzing the steps

implemented at EU level and Romania's capacity to adapt to the improvement of the fatal and non-fatal accident rate, this section proposes a model for the prevention and control of work accidents in Romania (European Statistics on Accidents at Work, 2018).

The EU Strategic Framework on Health and Safety at Work 2014–2020 provides for the following actions:

- In-depth consolidation of national strategies by reviewing EU member countries' strategies, creating a database that supersedes all the actions being implemented and conducting periodic meetings for debating the results.
- Facilitate compliance with OHS legislation at the level of all enterprises by offering ethnic support for implementing programs for risk assessment, developing good practice examples as the basis for different industries, promoting exchanges of best practices and actions that had results and continuing awareness campaigns.
- Implementation of OSH legislation at EU level by defining effective actions to reduce accidents and assess the effectiveness of sanctions and administrative fines.
- Simplify legislation by supporting member countries to identify regulatory complications created by their own transposing legislation.
- Treating the population aging phenomenon, managing new emerging risks, and preventing occupational illnesses
- Improving the collection of statistical data.

At national level, the strategic directions from EU are being pursued, with a series of activities being proposed, as follows (European Statistics on Accidents at Work, 2018):

- Legislative changes for a series of laws concerning the field of health and safety at work (Law 319/2006 on Occupational Safety and Health and Methodological Norms on Law Enforcement, no. 346/2002 on insurance against accidents at work and occupational diseases).
- Reviewing the legislative framework on occupational health services to simplify the procedure for reporting and declaring occupational diseases and updating the database of occupational diseases.
- Monitoring micro-enterprises and small businesses.
- Supporting employers to carry out prevention work.
- Increasing quality in different sectors of activity.

In order to develop a strategic model for the prevention and control of work accidents, a number of existing models in specialized literature have been evaluated. The first model underlining that the group of young people in Canada aged 15–24 was at a higher risk of traumatic occupational injury and a PICO framework (population, intervention, comparison, and outcome) had been developed. It was emphasized that specific indicators must be proposed to reduce the number of accidents, and the existing measures were not sufficient. Thus, it was underlined that legislative changes must be major, at the country level. In the research by Mehmood et al., the situation in Qatar, a high-income country, was presented and evaluated. In Qatar also, there were a number of challenges in ensuring the health and safety of the population. This research proposed a concerted action framework through multi-sectoral

involvement. This proposal underlined the importance of including the principles of damage control in the Qatar context. In the study presented by Kim et al., in 2016, emphasis was placed on developing a prevention and control model based on how to change safety cultures both in theory and practice at the workplace, and underlined the role of preventive culture at national level. Using empirical experience and analysis of previous models, it can be emphasized that legislation needs to be improved to prevent injuries at work. Improving legislation mainly refers to the proposal of measurable indicators that each sector of activity or company has to meet. The stages of the development of this model are—(1) the evaluation of the statistical data and of the existing legislation at EU and Romanian level; (2) focus group with experts from the Romanian Territorial Labor Institute; (3) systematization of the preventive and control framework; (4) theoretical pretesting of this model in 10 companies from the manufacture of motor vehicles, trailers, and semi-trailers (this model has been sent and OSH experts have amended and modified the model according to their own experience); and (5) finalizing the proposed model based on the empirical experience of the author. By evaluating the strategies and the evaluated statistical data presented above, at EU and national level, the author proposed a model for the prevention and control of work accidents (see Figure 1.78), especially for manufacture of motor vehicles, trailers, and semi-trailers . The basis for this model is EU legislation and national legislation. For these laws to be applicable at the enterprise level, organizational culture needs to be addressed and strengthened. The proposed model is based on four entities that complement and influence each other:

1. National legislation—the proposed framework takes into account all national legislation, being the basis of the present proposal. This entity is influenced by research and development (R & D) that can develop new methods for risk assessment. In turn, it influences R & D by developing new challenges to be addressed.
2. Stakeholders—they are among the most important parts of a company. They influence and are influenced by organizational culture, directly contributing to the development of new organizational strategies. Organizational culture includes the ethics and norms appropriate to a company and interacts, in particular, with shareholders and stakeholders within the organization. Organizational culture based on training and real occupational risk assessments contributes to reducing hazards and risk causes.
3. Personal motivation—according to the personal factor, the level of education of the employees, the model takes into account the typology of the employees of the field of activity. The level of education and training area contribute to the development of a competitive framework. This entity directly influences the preventative and control framework (indirectly by training level of the employees). The important factor to be taken into account is personal motivation, i.e., involvement of the employee in preventing accidents at work. As motivational factors, the human personality, cooperation, and ability to meet the requirements are part of the mandatory dimensions of personal motivation at work.
4. Research and development—this is the entity that influences and is influenced by national legislation and contributes to the development of new methods for risk management and prevention. It also influences the Shareholders of the organization.

At the same time, national legislation is based on EU legislative requirements. Actions help prevent and control accidents. Prevention and control influence EU legislation.

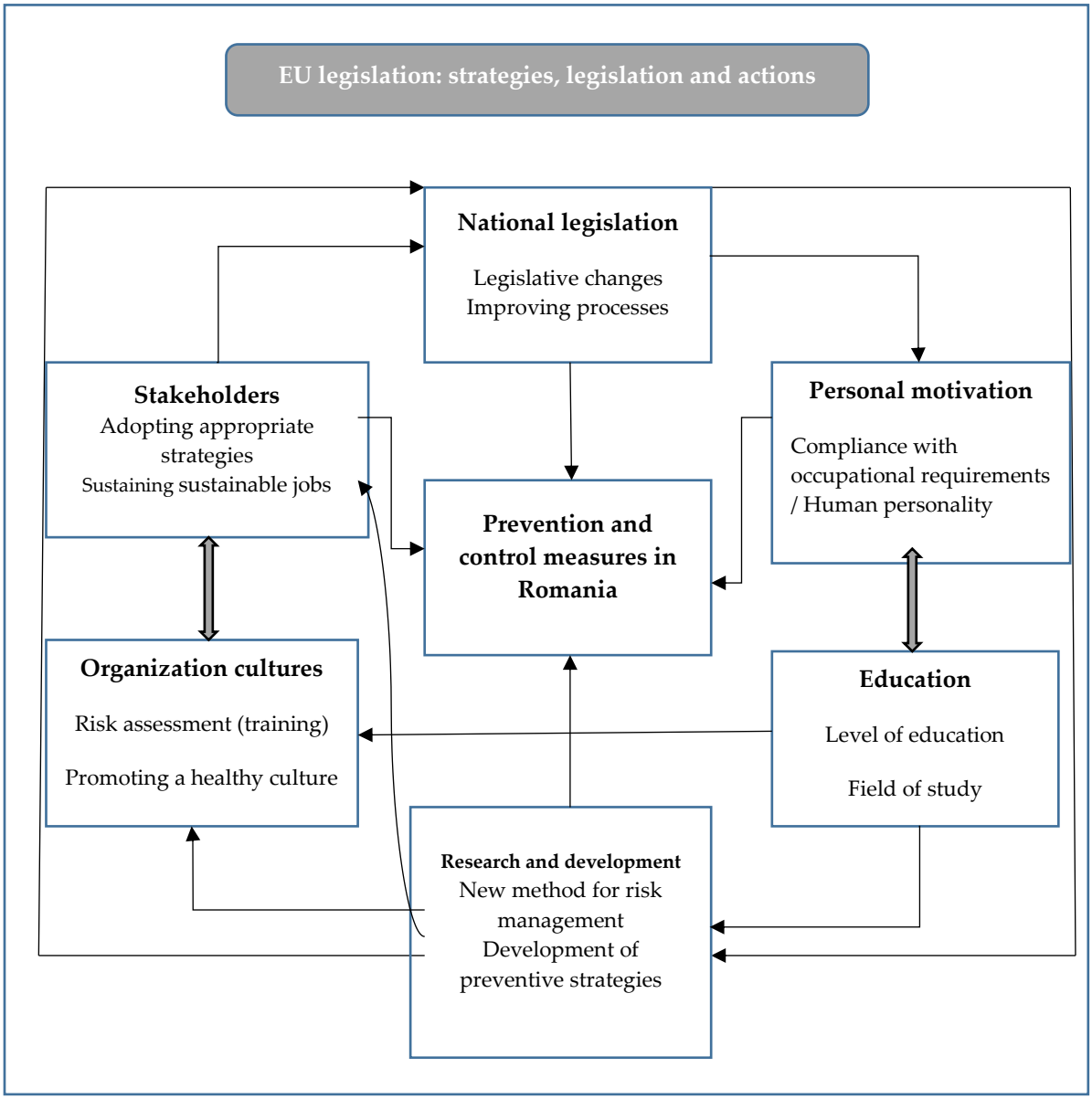


Figure 1.78. Investigation model for prevention and control.

Conclusions

As a result of the evaluation, we can see that the intensification of the activity of the industries will lead to an increase of the number of occupational accidents. In line with the existing (European Statistics on Accidents at Work, 2018) projections, industry will grow, the number of employees will increase or the level of automation will increase; thus, prevention actions are those that need to be implemented at the organizational level. Prevention actions involve avoiding risks, assessing those risks that cannot be avoided, tackling the risks at source, implementing innovation, prioritizing improvement actions, replacing hazardous substances with some less dangerous ones, and implementing global policies that integrate organizational values.

Involvement of organizational culture and individual motivation can help reduce the impact of occupational accidents. The existence of an investigative model helps managers to understand the steps that contribute to reducing accident rates. The next step consists in detailing the investigative model and its application in practice. As a result of the application, the necessary changes and correlations will be made, and then a complex model for the prevention and control of workplace accidents will be proposed.

For the consistency of the presentation, some data series have been uniformed because the same indicator has different values in different data bases. Priority was given to the European Commission data.

The limitations of the work refer to the series of data that are incomplete for some countries or years. At the same time, some data series show differences, for the same period or country, depending on the source of the collection. Another limitation refers to the fact that many accidents are not reported (fact found in the national reports).

1.4.9. Risk Indicators and Road Accident Analysis

Road accidents are a major societal issue for every country. This section is to assess the number of traffic and road accidents depending on a series of variables (collision mode, road configuration, conditions of occurrence, road category, type of vehicle involved, personal factors, and length of time of the driving license) in Romania from 2012–2016. The analysis of the road accident trend identifies the causes of accidents, road safety performance indicators, and risk indicators. Having these identified data, a framework is proposed for improving the road safety system and reducing accidents. The Romanian Police, the National Institute of Statistics (NIS) in Romania, and the European Commission provided the data used for this analysis. The data obtained from these databases are analyzed and evaluated according to a series of variables. This part will outline an informative image of road accidents and establish a framework for reducing their effects in road transport. As a result of the analysis, we have seen that the combination of vehicles and personal factors influences the number of traffic and road accidents.

The purpose of this study is to evaluate road and traffic accidents in order to get a picture of performance and safety in Romania. Performance refers to the best results/characteristics obtained on roads in Romania. To accomplish this goal, the presented study evaluates and analyses the trend of road accidents in the period 2012–2016. Road accident assessments identify the causes of accidents, road safety performance indicators, and risk indicators. At the end of the section, a framework for improving the road safety system is proposed.

In this study, the qualitative and semi-quantitative method was used to interpret the statistical data on the number of traffic and road accidents in Romania. From the statistical data, the selected variables for analysis included collision mode, road configuration, conditions of occurrence, road category, type of vehicle involved, personal factors, and length of time of the driving license. For statistical analysis, the period 2012 to 2016 was chosen. The analysis of the road accident trend identifies the causes of accidents, road safety performance indicators and risk indicators. Analysing and evaluating the data lead to obtaining a framework for the

improvement of the road safety system and reducing accidents, which is included in this research.

To clarify the position of Romania regarding the subject of road accidents, a series of data about other European Union (EU) Member States will be presented. The data used in this research was selected and collected from the databases related to the following entities: data from the European Commission (European Commission, 2017), the National Institute of Statistics (NIS) in Romania (National Institute of Statistics (NIS), 2017), and the Romanian Police (Traffic Police. Statistics, 2017). These collected data are evaluated and analysed to identify the causes of accidents, road safety performance indicators, and risk indicators. For the clarity and accuracy of the identification process, a number of variables were used to analyse and evaluate the collected data. The variables were established according to the priorities of the European strategy (European Commission, 2019) and the literature (Yau, 1996; Shankar et al., 1996; Karlaftis, and Tarko, 1998; Bin Islam et al., 2008; Pardillo-Mayora, et al, 2010; Savolainen et al., 2011; Yannis et al., 2014; Kumar et al., 2015; Alonso, 2017)

Literature review

Road and traffic accidents involve uncertainty and are unpredictable. These accidents are based on a number of causes that depend on a number of variables, such as: no priority to pedestrians, no priority to vehicles, the unlawful crossing of pedestrians, bicycle rider's deviations, speed not adapted to road conditions, deviations of the drivers of animal traction vehicles, and so on. It can be argued that road and traffic accidents are defined by a set of variables, some known and others unknown, which are more subtle (Yau, 1996; Shankar et al., 1996; Karlaftis, and Tarko, 1998; Bin Islam et al., 2008). Accident reduction and road safety are major concerns for public health. This statement is supported by statistics: over 3000 people from all over the world decease daily because of road traffic (Bin Islam, 2008). These road accidents cause a series of global economic losses estimated in road traffic damage costs of $518 billion a year. These huge economic losses contribute to the country's economic imbalance. In developing countries, the cost of road accidents is estimated to be $100 billion (Bin Islam, 2008). Besides these economic effects, road accidents also influence the demographics of each country. In this context, identifying strategies to counteract these effects is an important direction for each country.

In 49 studies from 13 countries, it was concluded that reporting injuries in official accident statistics is incomplete at all levels of severity of injuries. These reports found that there were differences compared with the real situation. It was found that 95% of the reported cases had lesions as follows: 70% serious injuries, 20% minor injuries, and 5% very slight injuries (Karlaftis, and Tarko, 1998; Bin Islam et al., 2008; Pardillo-Mayora, et al, 2010; Savolainen et al., 2011)

According to various road accident studies, there are a number of factors that influence these incidents. Environmental conditions, motorway design, type of accident, driver characteristics, and vehicle attributes are factors identified in research (Alonso et al., 2017). In another study (Lal et al., 2001), the factors that cause the severity of accidents in Hong Kong

were examined. The study (Russo et al., 2014) examined the impact of Spanish drivers' health, and the health conditions that could affect their physical ability to drive. It has been found that fatigue, alcohol, emotional state, sleepiness, headaches, respiratory illness, and fever are the most widespread diseases that affect the health of the driver. The intensity of driving and risk exposure is also a major cause of road accidents, and has implications for road safety (Lal, and Craig, 2001). Personal factors (age, experience, fatigue, health) influence the number of accidents (Russo et al., 2014; Useche et al., 2014; Westerman, and Haigney, 2000). It could be concluded that personal factors considerably affect the number of road accidents.

These factors are dependent on three types of vehicles: private vehicles, commercial vehicles, and motorcycles. The study highlights that each type of vehicle is associated with its own particular factors of severity. In the case of a personal vehicle, the severity levels of accidents were influenced by the driver's gender, the vehicle age, the driver's age, and street light factors. The factors that influence the accidents involving commercial vehicles are: the use of seat belts, the driver's health, vehicle age, the day of the week, and the time of driving. Road accident factors presented in another study include: time of the accident, location of the accident, road category, the guilty driver's age, vehicle characteristics, nationality, and driver experience (Wåhlberg, 2003).

In 2012, there were 5,710,773 registered vehicles, of which: 202,030—age ≤ 2 years, 677,031—age between 2–5 years, 1,732,941—age between 5–10 years and 3,098,771 over 10 years old. In 2016, the number of vehicles increased by 19%, reaching 7,010,608 vehicles. Of these there were: 254,042—age ≤ 2 years, 335,308—age between 2–5 years, 1,473,870—age between 5–10 years and 4,947,388 over 10 years old. It is noticed that the number of vehicles older than 10 years is increasing.

As a result of the evaluation of the specialised literature (Ratanavaraha, and Suangka, 2014; Cioca et al., 2015; Ambrus et al., 2017) it can be noticed that the road accident factors are mainly dependent on: the driver's experience, the environment of the accident, the road category, the driver's age, the type of the vehicle and the length of time from acquiring the driving license. Based on these factors, plus others proposed by the author, the road accidents in Romania will be analysed. Following the research, a framework for improving the road safety system in Romania is proposed based on a bibliographic review and qualitative and semi-quantitative statistical data analysis.

Study variables

For this study, seven variables were selected to assess and analyse road traffic accidents in Romania. Table 1.56 presents the variables used for the study, the types of each variable, and the implications of each variable. Having established these details, the results of the analysis are presented in the next section.

Table 1.56. The variables used in the present study

Variable	Variable Type	Variable Implication
Collision mode	Between vehicles Vehicle and pedestrian One vehicle	This variable highlights the severity of accidents according to the number of factors involved in the accident.
Road configuration	Curves Tunnel Intersections Bridges Crossing the railway Alignment	The most important road configurations that are involved in road accidents are these types. These are found on all road categories.
Condition of occurrence	Daylight Low brightness Darkness	The intensity of light within a day was considered to form the three categories of values for the condition of an accident occurrence.
Road category	Occurred on motorways Occurred in localities Occurred outside of localities	For this variable, the main values were considered depending on the intensification of the use of each type of road
Type of involved vehicle	car, van, bike, moped & motorcycle, animal traction, auto-trailer, intervention vehicle, and lorry/truck	All vehicle categories were considered as values for this variable. The type of vehicle involved in an accident is important for improving the road system on the direction of action
Personal factors	Age of the driver Gender of the driver	The two values for the variable were considered relevant for the improvement of the national road system.
Length of time of the driving license	Period of years	The length of time measured in years was considered for the evaluation of this variable.

Road Safety System Approach

Road safety is very important in every country because it affects the economic and social dimension of sustainable development (European Commission., 2017; National Institute of Statistics, 2017; Traffic Police. Statistics, 2017). Road traffic affects the environmental dimension of sustainability. Thus, it can be said that transport contributes directly to the sustainable development of a country (Salata et al., 2015).

The accelerated development of road traffic, along with the increase in its complexity and the intensification of drivers, draw/impose/suggest to automotive companies the approach of innovation in the production process and the increase of the quality of products and services. The action to prevent the severity of road accidents can be addressed from the perspective of actions that can be developed within the automotive industry (Ladeira et al., 2015).

In this research, the safety of the road system is assessed and improved in three directions: accident causes, road safety performance indicators, and risk indicators.

European Road Safety Strategy

The overall objective of the European Union is to reduce the number of road accidents by 50% by 2020. In 2010–2015, the EU recorded a reduction in deaths of only 17%, whereas a 29% decrease was needed to reach the 2020 target. Efforts in the field of traffic safety need

to be intensified globally, as over 1.2 million people die annually from road accidents. Death from road accidents is the main cause of mortality among young people aged 15–29, which is why this cause became a priority in the European strategy for 2030 (European Commission., 2017; National Institute of Statistics, 2017; Traffic Police. Statistics, 2017).

Globally, depending on the type of road variable, it can be seen from statistics that European roads remain the safest in the world. At the EU level, in 2016 there were 50 road deaths per million inhabitants, compared with 174 deaths per million globally (Salata et al., 2015).

In the year 2016, the ascending ranking per country according to the mortality rate for one million inhabitants highlights: Sweden (27), the United Kingdom (28), the Netherlands (33), Spain (37), Denmark, Germany (39), Ireland (40), Poland (79), Latvia (80), Romania (97), and Bulgaria (99). As the European strategy refers to the decrease in the number of accidents, an assessment of the situation in the different countries shows that some countries have seen a significant decrease in the number of road deaths, such as: Lithuania (22%), Latvia (16%), and the Czech Republic (16%) (European Commission, 2018).

Four EU member states have achieved a decrease in the number of accidents in line with the general objective: Denmark, Greece, Portugal and Spain. In relation to this objective, Romania recorded a 19% decrease in deaths by 2016 compared to 2010. Actions and approaches to this end are sustained at the national level, with real chances for achieving the EU's overall objective.

The situation of the member states in terms of achieving the overall objective is presented in Figure 1.79 according to the data provided by the European Commission. In this situation, two periods are evaluated: 2015–2016, and 2010–2016. Differences in the number of accidents per million inhabitants for the two periods are analysed. The result is expressed in percentage terms by 2015 for the period 2015–2016, and by 2010 for 2010–2016. For the period 2015–2016, it is noticed that Lithuania recorded the largest drop in road deaths per million inhabitants (22%), followed by Latvia (16%). In the antithesis, the largest increase in road deaths is registered in Malta. In 2016, there were 51 deaths per million inhabitants, up 20% compared to 2015, when 42 deaths per million inhabitants were recorded. For this period, 13 member states recorded an increase in the number of deaths per million inhabitants. This increase is in the range of 1–10%. In this situation, the EU's general objective can be achieved only with major investments in the infrastructure and actions of the countries (European Commission, 2018).

If the 2010–2016 period is analysed, the data provided in Figure 1.79 show that Portugal has the largest decrease in deaths per million inhabitants (40%), followed by Lithuania (37%) and Greece (35%). The largest increase in deaths per million inhabitants is recorded in Malta. This increase is 69% in 2016 compared with 2010 (European Commission, 2018).

At the EU level (Wells, 2007; Steenberghen, and López, 2008; Jama et al., 2011; Soehodho, 2017; Carozzi et al., 2017; European Commission, 2018) there are a number of actions and strategies proposed to achieve the overall objective. European road safety actions are structured in four major directions:

- A well-functioning internal market—harmonisation of transport requirements with infrastructure and industry capacity.
- Fair competition and workers' rights—developing a competitive business environment based on collaboration.
- Reducing greenhouse gas emissions—a 30% reduction in CO_2 emissions, as stipulated in the Paris COP21 agreement.
- Digital technologies—using innovations in the automotive field to increase road safety.

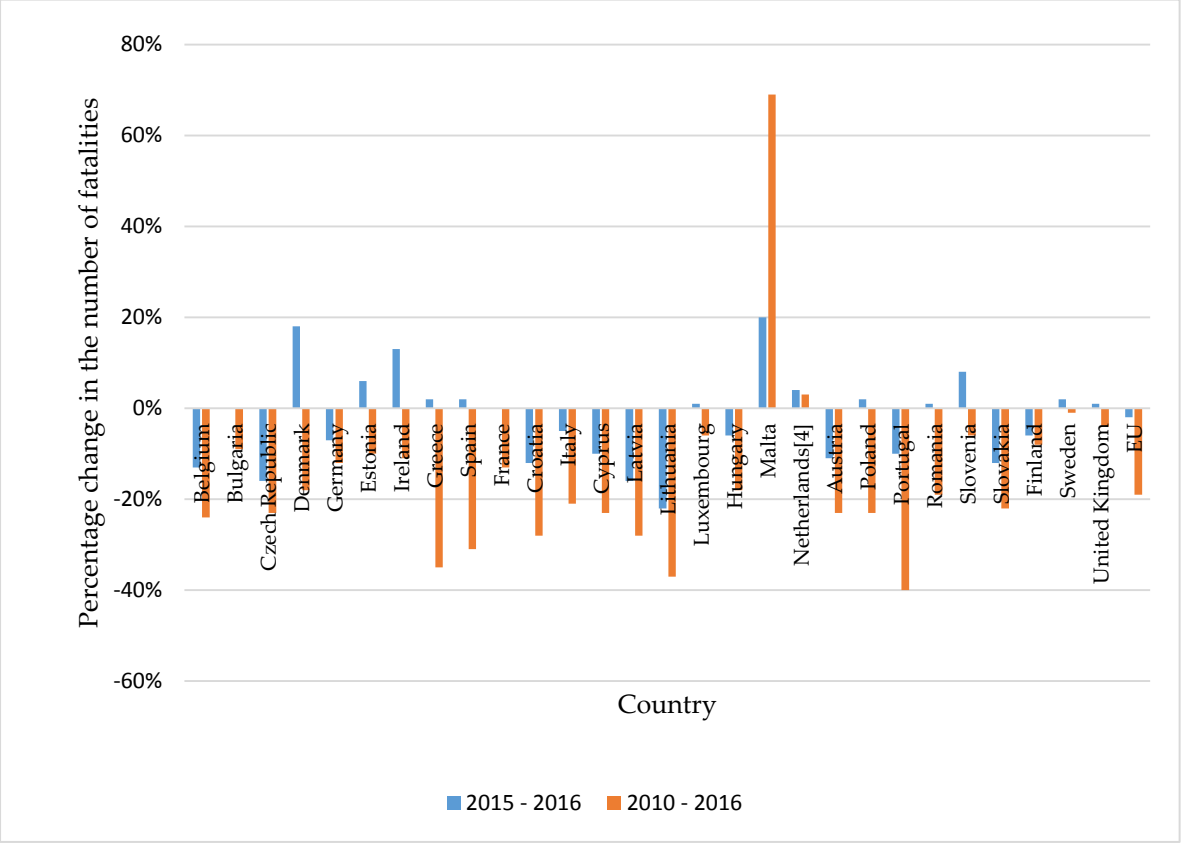


Figure 1.79. Number of road deaths per million inhabitants in the period 2015–2016 and 2010–2016 expressed as a percentage

Source: European Commission, 2018

National Road Safety Strategy

The overall objective of Romania's national strategy (Mikulik, 2009) which is aligned with the European strategy, is to reduce the number of deaths from road accidents by 50% by 2020, compared with 2010. In this respect, it is expected that in 2020 there will be no more than 1188 deaths, compared with the 2377 deaths registered in 2010. Among the specific objectives formulated in this direction are:

- Developing a road-safe country for its inhabitants, tourists, and investors by progressively reducing the number of road accidents in the period 2016–2020;
- Improving road infrastructure on all road types to reduce the number of road accidents;

- Building additional motorway kilometres and express roads to reduce the number of accidents;
- Operational coordination of integrated interventions through interoperability and cooperation between intervention services;
- Improving the emergency service by renewing the telecommunications infrastructure;
- Implementation of an integrated system of information and statistical data for the continuous monitoring of road accidents and related actions;
- Continuous improvement of the quality of the emergency medical act and of the intervention system;
- Carrying out actions to raise road safety awareness among children, adolescents, and students.

Results

This chapter presents the results obtained from the evaluation of the databases considered. The data are evaluated in the set of variables established and presented in Table 1.56. These data refer to road and traffic accidents registered in Romania. To support the presentation of road accident data, it is necessary to present the situation of existing road categories at the national level. Romania owns 86,080 km of public roads, of which 747 km were motorway in 2016 (see Table 1.57). About 90% of the national road network is at the single carriageway road standard, which significantly influences traffic safety. Table 1.57 presents the road categories in Romania for the period 2012–2016 (Zhao, 2009; Dalla Chiara, and Pellicelli, 2016).

It is noticed that the national roads are upgraded in proportion of 35% of the total public roads. The county and communal roads require improvements. This presentation of the road situation in Romania is closely related to the recorded accidents. The registered accidents are also dependent on the road category, and the road performance is directly proportional to the quality of the public roads.

Table 1.57. Road categories in Romania

Category of Public Roads	Improvement Status	UM	2012	2013	2014	2015	2016
Total	**Total**	**km**	**84,185**	**84,709**	**85,184**	**85,920**	**86,080**
	Upgraded	km	27,665	29,166	30,247	32,648	33,928
	Motorways	*km*	*550*	*644*	*683*	*747*	*747*
National	**Total**	km	16,887	17,110	17,272	17,606	17,612
	Upgraded	km	15,645	15,956	16,172	16,557	16,600
County and communal	**Total**	km	67,298	67,599	67,912	68,314	68,468
	Upgraded	km	12,020	13,210	14,075	16,091	17,328

Source: European Commission, 2018

Road Traffic Accidents Analysis According to the Established Variables

In this section, the data obtained from the database collections used for research are presented (Tähkämö, and Halonen, 2015). Road and traffic accidents are assessed based on the established variables. These data are analysed and evaluated in the discussion section.

Collision Mode

This section presents the data on the three types of collisions that may occur in road accidents: collisions between vehicles, collisions between a vehicle and a pedestrian, and collisions involving only one vehicle. Table 1.58 presents road traffic accidents causing bodily injury by their nature and how they occurred (Chubukov et al., 2017). It can be seen that collisions between vehicles account for over 40% of the total number of accidents recorded. Total accidents registered a decrease in the period 2013–2014, after which the number of accidents increased. Taking 2010 as the reference year, which is also a reference year for the European reports (regarding the achievement of the general objective), it is noticed that in 2013 there is a 4.5% decrease in the number of accidents. The largest increase is recorded in 2016, an increase of 12%. The variance between accidents in 2016 is +8.1% compared with 2012.

Table 1.58. Situation of road accidents depending on how they occurred

Collision Mode	2012	2013	2014	2015	2016	Variation (%) 2012–2016
Collisions between vehicles	11,932	11,128	11,432	13,540	13,690	+14.7%
Collisions between a vehicle and a pedestrian	8791	8301	8576	8995	9010	+2.4%
Collisions involving only one vehicle	6205	5398	5347	6409	6423	+3.5%
Total	**26928**	**24827**	**25355**	**28944**	**29123**	**+8.1%**
Dynamics compared to 2010, year 2010 = 100%	+3.5%	−4.5%	−2.5%	+11.3%	+12%	-

Source: European Commission, 2018

Road Configuration

From the road configuration perspective, the main types of road accidents are road alignment (71%), curves (18%), and intersections (9%). Table 1.59 presents the situation of deaths and injuries according to the characteristics of the road for 2016 (Feniser et al., 2017). The 2012–2016 period is taken into account. In 2012, there were 36,251 accidents, which included 2042 deaths and 34,209 injuries. For 2016, there is a 6.7% increase in incidents.

Table 1.59. Situation of deaths and the number of injuries depending on road configuration

Characteristic	No. of Deaths	No. of Injured
Curves	2353	8917
Tunnel	16	82
Intersections	1135	8405
Bridges	117	330
Crossing the railway	147	135
Alignments	9144	33,653
Total	**12,912**	**51,522**

Source: European Commission, 2018

Conditions of Occurrence

The situation of accidents according to the occurrence conditions is presented in Table 1.60 (Chubukov et al., 2017). The process conditions of the accidents considered for the assessment are: daylight, low light, and darkness. The highest number of road accidents is recorded during the day (that is daylight). Darkness brings the least road accidents for the entire analysed period 2012–2016. The total accident rate variation in 2016 compared to 2012 is +8.1%.

Table 1.60. Situation of road accidents depending on occurrence conditions

Conditions of Accident Occurrence	2012	2013	2014	2015	2016	Variation (%) 2012–2016
Daylight	18,866	17,494	18,012	20,768	21,121	+11.9%
Low brightness	5677	5167	5152	5770	5801	+2.1%
Darkness	2385	2166	2191	2406	2201	+7.8%
Total	**26,928**	**24,827**	**25,355**	**28,944**	**29,123**	**+8.1%**

Source: European Commission, 2018

Road Category

Depending on the road category, the registered accidents are evaluated within the three categories of accidents produced on motorways, in the locality and outside the locality (Cheng et al., 2015). These accidents are presented in Table 1.61. It is noticed that most accidents are produced in the locality, followed by those outside the locality. The density of road accidents in relation to km of motorway shows a value between 3.71–4.73. Accidents in localities show an increase of 11% compared with 2012. The period 2013–2014 is one that has a decrease in the number of accidents. Starting with 2015, the number of accidents increases considerably. This is due to the increase in the number of vehicles by 12% in 2015 compared with 2012. In 2015, there were 6,600,325 registered vehicles, and in 2012 there were 5,710,773 registered vehicles.

During the analysed period, there were decreases in accidents on the streets and county roads, and increases in the accidents on the communal roads and other categories of roads (European Commission, 2018). The death rate on national roads is higher than the average for all other categories. At the national level in 2016, the death rate for national roads was 0.09 per km compared with the average of 0.04 per km for all roads. The variation of the road accidents according to the place of production is + 8.2% taking into account the years 2012 and 2016.

Table 1.61. Situation of road accidents according to the place of occurrence

The Place Where Accidents Occur	2012	2013	2014	2015	2016	Variation (%) 2012–2016
Occurred on motorways	131	136	129	175	201	+53%

Occurred in localities (excluding motorways)	22,108	20,541	21,080	23,921	24,568	+11.12%
Occurred outside of localities (excluding motorways)	4689	4150	4146	4848	4354	−7.2%
Total	**26,928**	**24,827**	**25,355**	**28,944**	**29,123**	**+8.2%**
Km of motorway	550	644	683	747	747	+35.8%
Density of road accidents reported per km of motorway	*4.19*	*4.73*	*5.29*	*4.26*	*3.71*	*+14.5%*

Source: European Commission, 2018

Type of Vehicle Involved

The Romanian motor vehicle fleet increased by 21.8% in 2015 compared with 2010. One third of the cars registered in Romania are over 15 years old. In the year 2016, the trend of cars is an upward one, with the fleet registering more vehicles older than 10 years (Cheng et al., 2015).

An important part of this variable is bicyclists and small vehicles (moped, motorcycle). The types of variables considered in this analysis are: car, van, bicycle, moped and motorcycle, animal traction, auto-trailer, intervention vehicle, and lorry/truck. Vehicle typology is presented in Table 1.62 (Cheng et al., 2015). Since the number of bicycles is increasing [20] as a result of various actions related to sustainable development, the number of accidents involving bicycles is considerable, and 19–27% of the bicycle accidents involve cars. The fewest accidents are registered for auto-trailers, intervention vehicles, and lorries/trucks.

Table 1.62. Typology of vehicles involved in road accidents in 2012–2016

Variable Type	2012	2013	2014	2015	2016	Variation (%) 2012–2016
Car	4427	3590	3470	4511	4670	+5.4%
Van	570	636	726	732	756	+32%
Bicycle	634	858	944	912	898	+41%
Moped & Motorcycle	860	598	559	560	589	−32%
Animal traction	258	245	212	260	273	+5.8%
Auto-trailer	82	151	139	142	147	+79%
Intervention vehicle	38	34	48	52	54	+42%
Lorry/truck	23	47	40	43	47	+104%

Source: European Commission, 2018

Personal Factors

Personal factors considered for assessing the trend of road accidents and for identifying risk factors are the driver's age and sex.

These types were chosen for the "*personal factors*" variable because it was found (Cheng et al., 2015) to be the most important data for road accident analysis.

A. Driver's age

From the perspective of personal factors, the distribution by age groups of drivers is presented in Table 1.63 (Torreta et al., 2017). According to data provided by the Romanian Police, people over 65 have the highest risk of death. This share in total road deaths is higher than the share of total population (21.4% vs. 15.4% of the population). This distribution refers to serious traffic accidents for which the offense has been established by the competent authorities. Most accidents occur in the 26–35 years and 36–45 years categories. According to the data provided by NIS, these age classes drive most vehicles. We chose to analyse the years 2012 and 2016 because there are no relevant data for the years 2013, 2014, and 2015.

Table 1.63. Situation of accidents by age category

Age Category	2012		2016	
	Involved	Involved with Guilt	Involved	Involved with Guilt
< 18	26	21	32	26
18–25	1811	1142	1922	1252
26–35	2705	1467	2804	1535
36–45	2211	1088	2397	1191
46–55	1497	899	1637	907
56–65	1042	611	1048	625
66–75	312	208	328	226
> 75	71	56	82	58

Source: European Commission, 2018

B. Gender of the driver

Depending on the gender of the vehicle driver, Table 1.64 lists fatalities and serious injuries (Cheng et al., 2015). From the data, men are involved in 75% of deaths and 65% of serious injuries. For 2016, data on deaths and injuries are not public. There were about 7.14 million people holding a valid driving license and registered in Romania on 31 December 2016, of whom 4.84 million were men.

Table 1.64**.** Deaths and serious injuries by sex

Year	Deaths		Serious Injuries	
	Masculine	Feminine	Masculine	Feminine
2012	1542	500	5783	3077
2013	1374	487	5164	2994
2014	1361	457	5204	2918
2015	1356	455	5197	2903
2016	-	-	-	-

Source: European Commission, 2018

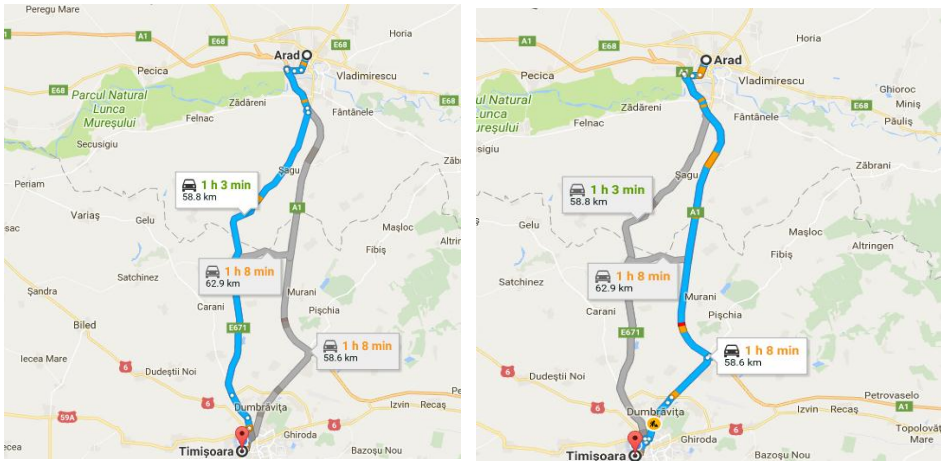
Length of Time of the Driving License

Regarding the length of time since obtaining the driving license, most accidents are produced by drivers with one-year-old driving licenses. They are followed by those who have six-year-old driving licenses. One-year-old drivers are involved in road accidents on all road categories. The frequency of involvement in road accidents is higher with less experienced drivers (Vilela da Silva et al., 2017).

Case Study: Assessing Accidents on a Road Section

For this case study, we have selected two roadways located in the Western Region of Romania. These road sections link the two cities of Timisoara and Arad. One of these sections is composed of national and European roads, and the second is the A1 motorway. These road sections are identified with the most severe accidents, and the causes of accidents and risk indicators are assessed. These road sections connect two major cities in the West of Romania.

The connection between the two cities, Timisoara and Arad, can be covered via DN69/E671 (58.80 km) or Via A1 (58.60 km). The Timisoara–Arad motorway section was put into operation in December 2011 and has a length of 38.9 km. The difference is that this section is covered by the European national road DN69/E671. According to the data provided by Google Maps, the time duration is close for the two routes. This is because the European national road to the highway entrance is very crowded. It takes about 20 km to enter the highway. It is appreciated that on this 20-km portion, the running speed is below 40–50 km/h. In order to investigate whether there are different risk factors for injury, two types of roads were considered (national/European and motorway). These road sections are shown in Figure 1.80



(a) (b)

Figure 1.80. Roadway chosen for studying Timisoara—Arad: (a) the European national road (via DN69/E671); (b) the A1 motorway (Google Maps capture)

The accidents that occurred on these road sections were analysed from the perspective of the variables used and data analysis for 2012–2016. In addition to these variables, the severity of the impact was used to identify whether the accident resulted in deaths or injuries only. The data provided by the Romanian Police were used to assess accidents. The analysis period is 2016 on accidents declared publicly (Ivascu et al., 2014) For the two variants of the section, 50 accidents were randomly considered that took place at different times of the year. The following are the results obtained (Ivascu et al., 2014) according to the evaluation:

A. European national road via DN69/E671

- Type of collision: 70% of the accidents occurred as a result of collision between two cars, and 20% as a result of collision with road furniture.
- Road configuration: 90% of road accidents were caused by road alignment.
- Conditions of occurrence: 45% of accidents occurred in daylight, and 35% in low light.
- Road category: 30% in localities and 70% outside localities.
- Vehicle type involved: 65% cars, 45% animal traction, 55% bicycles. In this variable, it was considered that in an accident where there may be a collision between a car and a vehicle with animal traction, taking into account both variants is considered in the expressed percentage.
- Personal factors: most accidents have been committed by drivers in the following age categories: 26–35, 36–45, and over 56 years. In the situation of collisions with animal traction vehicles, the driver's age is over 56 years.
- Driving license length of time: one year and over six years. In vehicles with animal traction, the experience cannot be accurately determined (the duration of use is over 15 years of use of the vehicle).

B. A1 motorway

- Type of collision: 95% of accidents occurred as a result of collision between two cars and 5% as a result of collision with road furniture.
- Road configuration: 60% of road accidents were caused by road alignment, 40% due to non-compliance with the role of the emergency lane.
- Conditions of occurrence: 85% of accidents occurred in the daylight.
- Road category: 100% outside localities.
- The type of vehicle involved: 65% cars, 55% intervention vehicles, 50% auto-trailers and 35% lorries/trucks. In this variable, it was considered that in an accident there may be a collision between a car and a truck, taking into account both variants in the expressed percentage.
- Personal factors: most accidents were committed by drivers in the following age categories: 26–35, 46–55, and 56–65 years. The age of drivers of trucks, auto-trailers and intervention vehicles is in the 56–65 years category.
- Driving license length of time: over six years. The driver's duration of use for trucks, auto-trailers, and intervention vehicles is over 10 years.

The Performance of the Romanian Road System and the Risk Factors

This subchapter identifies road safety performance indicators, risk indicators, and causes of accidents. The causes and indicators are identified based on road accidents assessment and the case study from the Western Region of Romania. In order to create a complete picture of road transport in Romania, it is necessary to analyse the most important performance indicators that contribute to the competitiveness of the road system.

Road safety performance indicators highlight those optimal operating conditions of the road traffic system that influence system security performance and serve as evaluation tools (Ivascu, and Cioca, 2014) It is noted (Korchagin et al., 2014) that the following are among the most important performance indicators:

- Daytime usage of low beam light on all road categories—using daytime low beam lights helps reduce the number of accidents.
- The degree of use of seatbelts on all road categories—the percentage of use of seatbelts on motorway roads is more than one third higher than the one on national/European roads.
- Average running speeds—average running speed for vehicles is 33 km/h in localities, 66 km/h on national/European roads, and 124 km/h on motorways.
- The number of kilometers covered annually—cars register up to 15,000 km a year, heavy vehicles about 35,000 km, buses 50,000 km.
- The current state of the auto fleet in Romania has seen a considerable increase in vehicles over 10 years old over the last 10 years.
- Vehicle equipment contributes to driving performance on all road categories due to the comfort and special features offered to the driver (lane keep assist, rain sensors, driver fatigue warning, etc.).

All exposures related to road accidents that contribute to the emergence of risks to human health should be considered risk factors. The risk factors (Cioca et al., 2007; Cioca, and Moraru, 2010) that are required to be monitored in a safe road system are:

- The driver's behaviour, including: individual risk factors, administered drugs, tiredness, lack of experience, drink, hearing and visual impairment, the use of mobile phones, distributional attention, health status, and more.
- Vulnerable road traffic subjects include: pedestrian behaviour, unattended children, and older road users.
- Protective behaviours, including all tools that help reduce the likelihood of a road accident.
- Environment, including all attributes related to the environment, road condition, and other adjacent elements.

The causes of accidents are directly proportional to the variables analysed in this section. The most important causes of accidents include: infrastructure (the reduced number of km of motorway), vehicle state (Romania fleet has grown in recent years, and vehicle age is over 10 years), and personal experience (which is different from one driver to another). A description of these causes by category of road is presented in Table 1.65. These data refer to the year 2016.

Table 1.65. The main causes of road accidents by category of road

Road Category	The Main Cause	Percentage Cause/Road Type
Street	No priority to pedestrians	21%
	No priority to vehicles	15%
	Unlawful crossing of pedestrians	23%
	Bicycle rider's deviations	12%

National road	Speed not adapted to road conditions	25%
	The irregular crossing of pedestrians	13%
	Non-regulatory overtaking	10%
County Road	Speed not adapted to road conditions	30%
	The irregular crossing of pedestrians	15%
	Bicycle rider's deviations	10%
Communal road	Bicycle rider's deviations	25%
	Speed not adapted to road conditions	18%
	Deviations of the drivers of animal traction vehicles	13%
Motorway	Failure to observe the distance between vehicles	25%
	Speed not adapted to road conditions	20%
	Attention distraction with other activities	15%

Source: European Commission, 2018

It is important to monitor and improve the road performance indicators in order to reduce risk factors, address the causes of risk, contribute to increasing road safety, and achieve the EU's objective of reducing road traffic accidents by 50% by 2020 compared with 2010 (European Commission, 2018)

Improvement of Road Safety System

Following the analysis, the road safety system can be improved. These improvements are related to the driver, vehicle, and road safety specialist. This proposal is presented in Figure 1.81.

This proposal focuses on a series of elements of compulsory systematisation in the form of a pyramid on which four areas are concerned: EU objective, Risk management, Road safety education, and Law.

For the pyramid, there is an analogy with Maslow's Pyramid (Chubukov et al., 2017) which requires a series of fundamental needs. In the case of this proposal, there are vehicle and infrastructure needs. If these needs are met, the security level is passed to the next level by awareness of the human factor. The last level that needs to be met is that of safe speeds adapted to previous needs. This pyramidal system acts on the four areas that contribute to the competitiveness of the road system, and to the reduction of road and traffic risks.

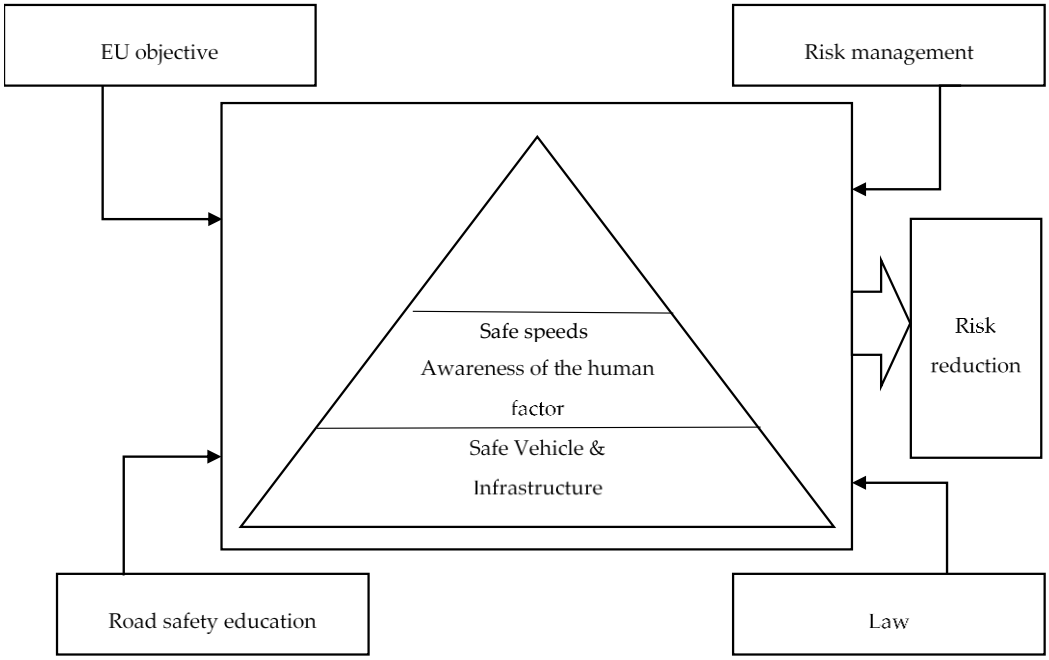


Figure 1.81. The proposed framework for improving the road safety system

Discussion

Within this chapter, the results obtained in the previous section are discussed. Discussions are structured on the addressed topics and supported by arguments:

- In terms of collision type, 47% of road accidents occur as a result of collision between vehicles. This is also supported by studies conducted in this respect.
- Curves are the cause of the most accidents when considering the road configuration. Thus, 2353 deaths and 8917 injuries were recorded in the year 2016.
- During the entire analysed period, accidents occurring in the daylight are those that occur most frequently. The number of road accidents according to the configuration in 2012 is 26,928, and in 2013 and 2014 there was a decrease in the number of accidents. However, in 2015, these kinds of accidents become more frequent again. In studies (Cheng et al., 2015), daylight is an important factor in monitoring road safety.
- The number of accidents caused by motor vehicles is in the range of +5.4% in 2016 compared with 2012. The number of accidents is increasing over the last two years as a result of overcoming the impact of the economic crisis and the increase in the number of vehicles in the Romanian fleet.
- More than 60% of serious accidents took place on national roads and streets, resulting in three quarters of the number of serious injuries and deaths.
- Drivers aged between 26 and 45 are involved in most road accidents. From the perspective of gender, men are involved in 75% of road accidents. Studies show that women exhibit balanced behaviour leading to a decrease in the number of their implication.

- Most accidents are caused by low-skilled drivers, with less than six years of driving experience. The length time of the driving license highlights that human experience contributes to increasing positive results.
- 55% of the injuries produced on DN69/E671 resulted in the death of at least one person.
- 85% of the accidents produced on the A1 motorway resulted in the death of at least one person.
- It is seen from the literature that physical and mental health influence the number of accidents.
- By properly monitoring the health status of drivers, the number of accidents could be lower.
- Road quality and country strategy contribute to improving road performance and safety.

Road safety performance indicators provide the best conditions for safe traffic. The assessment of these factors contributes to increasing safety and reducing the impact of risk indicators.

Risk indicators are presented to highlight the importance of risk management in the field of road safety. It can be concluded that through improved risk management, the road safety system in Romania can be greatly improved. Under these circumstances, the EU target of 50% reduction in road accidents by 2020 compared to 2010 can be achieved.

Achieving the EU objective contributes to the alignment of the country with European standards and requirements, and to the sustainable development of the country.

Conclusions

The progressive reduction in the number of road accidents in the period 2016–2020, the central objective of the strategy, is at the same time the main result that can be expected from the sustainable development of a country. Sustainable development of an entity should consider the assessment of all risks and activities related to the human factors.

Most road accidents are caused by human behaviour with certain deficiencies. That's why its correction is of great importance. In Romania, a considerable number of road accidents are due to personal factors. To improve the current situation, the national road safety and security strategy must include infrastructure investments and raise awareness for the drivers of the importance of physical and mental health monitoring.

The limitations of this study refer to the fact that the data used was taken from the European Commission, the National Institute of Statistics (NIS) in Romania, and the Romanian Police, and these represent the data declared by authorised institutions.

1.4.10. Risk Management and an approach for introducing functional safety in the development of automotive E/E systems

In the context of sustainable development, functional safety research in automotive industry is very important. Functional safety proves to be one of the key issues of future automotive development especially taking into account the technological advances. The technological complexity of the software content and the implementation of various concepts, determines an increased risk of introducing potential faults leading to malfunctions of the E/E systems. So

automotive vehicle manufacturers and suppliers are taking steps to implement ISO 26262 to avoid the risk of losing their competitive edge. This part aims to be a support for the first introduction in the development of products and processes compliant with ISO 26262 requirements.

Worldwide there is evidence that there are approximately 1.3 million deaths / year due to road traffic. So automotive industry is under pressure to deliver new and improved systems for the safety of vehicles, ranging from airbag systems to extremely complex systems advanced driver assistance with prediction and accident avoidance capabilities (Moraru et al., 2014; Becker et al., 2017). From this need arose ISO 26262 (ISO 26262, 2011) as an adaptation of the generic standard IEC 61508. ISO 26262 is the standard for functional safety applications in road vehicles. The functional safety standard ISO 26262 is not intended to be used only for the systems related to safety of the vehicles but for all the E/E systems of a vehicle that could subject the vehicle occupants, other road users, pedestrians and vehicle technicians to unreasonable risk due to a malfunction. The implementation of this standard is complex and affects the entire product life-cycle management (Mauborgne et al., 2016). This standard provides requirements to perform functional safety assessments and provides automotive-specific analysis methods to identify the automotive safety integrity level. In literature it is found that "ISO 26262 is considered to represent the "state of the art" for the development of vehicle electronic systems, specifically of safety relevant systems in passenger vehicles (Ward D. et al., 2013). It is an important standard for the functional safety of current applications that integrate technological advance (D. Ward, et al., 2012).

This section proposes a framework for assessing the implementation of ISO 26262 requirements. In this regard a literature research is made and finally the framework for ISO26262 implementation approach is presented. The proposal is based on literature review and practical experience in this area.

The steps of this research are:

- Literature review
- System development necessities identification
- Stages of implementing ISO 26262
- The benefits of implementing this standard.

Further the framework for the ISO 26262 implementation and the necessary requirements are presented. Needs are identified for the system development depending on the system status (new development E/E system or modified E/E system).

Proposal of a framework for identification of ISO 26262 necessity to be implemented

The implementation of ISO 26262 aims to achieve "absence of unreasonable risk due to hazards caused by malfunctioning behaviour of E/E systems" (ISO 26262, 2011). The automotive functional safety standard ISO 26262 addresses the safety related electrical or electronic (E/E) systems that are part of general purpose passenger cars, produced in series.

The automobiles category for which the standard is applied is further limited to a maximum vehicle mass of 3 500 kg and special purpose vehicles are excluded (Marcher et al., 2015).

The proposed approach (see Figure 1.82) implies the following process:

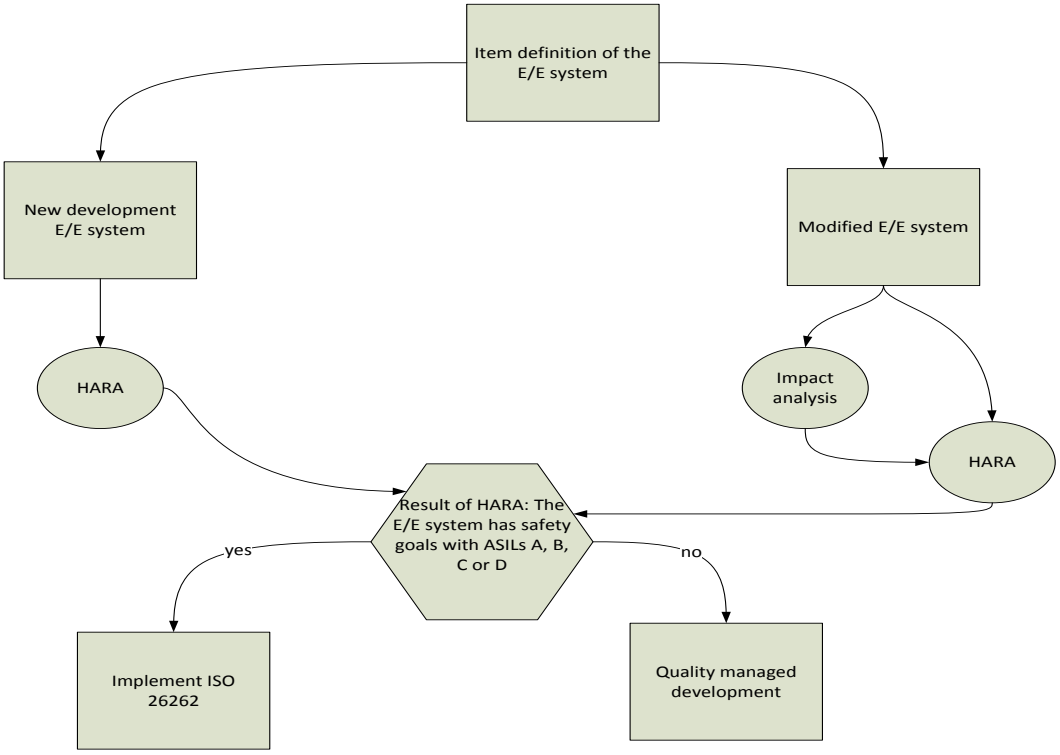


Figure 1.82. Proposal of a workflow to identify the need of ISO 26262 implementation

The starting point of the analysis of the product, to determine if the standard should be considered, is identifying if the product contains any electrical or electronic elements. The E/E system (electrical and/or electronic system) refers to a system that is composed of electrical or electronic elements.

1. First an item definition is developed and in order to determine what type of development category the E/E system represents. An item is defined by the ISO 26262 as being composed of one or multiple systems that have the role of implementing a vehicle level function, for which the standard is applied, or at this development stage, it could be applied. The item definition has the purpose of defining and describing the item, its interfaces and interaction with the environment and other items and also clearly determining the boundary of the item in the system architecture, to facilitate the understanding of the item so that the next activities can be performed.

    a. If it is a new development system then a **hazard analysis and risk assessment** needs to be developed using the inputs from the item definition. The purpose of avoiding unreasonable risk is supported by performing a hazard analysis and risk assessment to determine the safety goals of the item and their respective ASILs (automotive safety integrity level). The analysis is performed at the vehicle level functional behaviour of the item, so the detailed design of the

system does not necessarily need to be known. This supports the recommendation that the analysis should be made at the incipient phase of the product development, in the innovation/prototype phase. The potential hazardous events of the item are systematically evaluated and the safety goals together with their ASILs are determined. The impact factors determining the ASILs are severity, probability of exposure and controllability.

b. If it is a modification of a pre-existent system then the reused part need to have been developed before 2011 (the publication date of the standard) or to have been implemented according to ISO 26262. For the modified part of the system, an **impact analysis** shall be carried out. The purpose of the impact analysis is to identify all the modifications that impacts the item or its environment, to describe them and to evaluate what is their impact on the system. Then also a **hazard analysis and risk assessment** will be developed, using the inputs from the impact analysis and the item definition.

2. The result of the hazard analysis and risk assessment determines the necessity of implementing the ISO 26262 standard. The hazard and risk assessment output consists of top-level safety requirements called safety goals that have an ASIL assigned. Due to the fact that the hazard analysis and risk assessment determines actually the necessity of ISO 26262 application to the developed system, the standard mandatory requires that this analysis is verified by a person from a different department or organization, that has the highest degree of independence related to the department responsible, the development team of the system, their management and release authority.

    a. If the ASIL classification is A, B, C or D, then the ISO 26262 requirements implementation is necessary.

    b. If the ASIL classification is QM (quality managed) then the quality management system of the company is sufficient to achieve the safety requirements of the product and the ISO 26262 specific requirements do not need to be implemented.

Proposal of a framework for ISO 26262 implementation

For the situation when the implementation of ISO 26262 is required, the following approach is proposed.

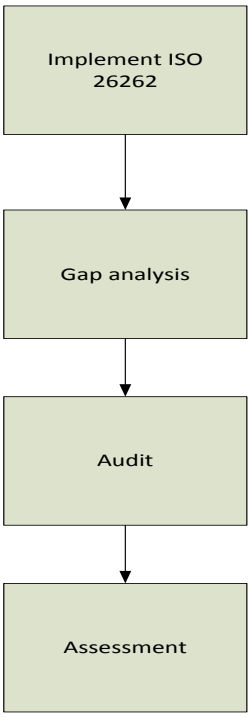


Figure 1.83. The proposed stages for implementing ISO 26262

If the hazard analysis and risk assessment determines a safety goal with ASIL A, B, C or D, then the processes and product need to be aligned and developed according with ISO 26262.

In order for the product development life-cycle process to be aligned to the automotive functional safety standard, the first step is to establish a baseline level of conformance to the requirements of ISO 26262 by conducting an informal "**gap analysis**" of the existing processes. The gap analysis will not provide a requirement- by- requirement check but rather focus on high level process conformance against the intent of the standard. In case the processes exists but they are not formally documented, a high level diagram describing the process needs to be prepare in advance of the gap analysis that will contain a summary of required inputs, expected outputs, how the processes are executed, what resources are required (e.g. tools, equipment), who uses the process (e.g. roles, responsibilities, competencies), how the process is measured (KPIs etc.). A report of the gap analysis will show the major gaps in the process related to ISO 26262 requirements and corrective actions to develop or update the processes covering the gaps will be taken following the analysis.

In case the highest ASIL of the item's safety goals is ASIL (B), C, or D a functional safety audit is required by the ISO 26262 standard to be carried out. An audit is considered to be an examination of an implemented process. A functional safety audit is performing an evaluation of the implementation of the functional safety processes (Ivascu et al, 2014), during the execution of these processes, that have to be according with the activities specified in the safety plan. The audit will analyse the implemented process by checking each requirement of ISO 26262. The audit will have inputs from the gap analysis if available. The report of the audit

will contain all the findings identified during the audit and corrective actions for solving the findings will need to be taken.

In case the highest ASIL of the item's safety goals is ASIL (B), C, or D a functional safety assessment is required to be carried out. The functional safety assessment is an evaluation of the compliance of the work products required by the safety plan with the corresponding requirements of ISO 26262, also it is an analysis of the implementation of the functional safety processes, taking into consideration the findings from previous functional safety audit(s). The functional safety assessment also performs a review of the implemented safety measures efficiency.

The above framework can also be applied even for generic elements that are developed independently. In this case, assumptions will be made regarding requirements and interfaces. These then will be customized and adapted for the required applications. Developing the generic elements according to the ISO 26262 standard before their integration is required and known, could provide a real competitive advantage against other suppliers of similar elements.

Following the implementation of the standard, a series of benefits are obtained:

- Reducing the risks of system malfunctions
- Identifying and managing/accepting the residual risks
- Product developed according to "state of the art" in automotive industry
- Increased competitiveness of the product on the market

Some of the challenges of implementing the standard are:

- Small companies will need external support for achieving review/audit/assessment independence requirements
- The consideration of ISO 26262 needs to be made very early in the development phase, starting with the prototype idea due to cost and resources implications

From the proposed framework it is observed that implementing the ISO 26262 standard is not an obligation for all organizations developing E/E systems, but only for those that following the hazard analysis and risk assessment have safety goals of their item with ASILs different than QM.

From the steps indicated in the framework for adapting an existing product development process to the requirements of the ISO 26262 standard is can be observed that the challenges could have a major impact in the planning from the most incipient phase of the development and that following the proposed systematic approach will offer a "state of the art" process that can support highly competitive product development.

Future research directions could be focused on detailing the actual impact and means of overcoming the challenges of implementing the standard, and also the methods of performing at the highest quality level the most important analysis of the system determining the adaptation of ISO 26262, the hazard analysis and risk assessment.

Sustainability education contributes to the competitive development of organizations, sustainability can develop a number of organizational models, and risk management contributes to the treatment of risks through appropriate analysis. In this sense, this last section presents a series of organizational strategies in the current context of the circular economy.

1.5. Organizational strategies in the context of the circular economy

1.5.1. Strategies, Sustainable Development and Technological Impact on CO_2 Reducing Conditions in Romania

Climate change is a reality all over the world, and its complexity is increasing. Therefore, sustainability has become a national and international concern, ingrained in many organizational processes. The ability of organizations to respond to sustainability concerns is sometimes hindered by the complexity of integrating sustainability into business models and by the need to rethink their strategic directions. In Romania, sustainable development has become a priority for businesses, but even though companies are showing some concern, there are yet to demonstrate any full commitment (they are mainly concerned with areas such as society and the environment). This part assesses Romania's involvement in the adoption of actions directed toward the reduction of pollutants and greenhouse gases, namely actions focused on reducing the main causes of pollution. This analysis compares the situation in Romania with that of the European Union. The main concerns can be categorized according to four sectors, which produce the highest quantity of carbon dioxide emissions in the world: the energy sector, the transport sector, the waste sector and the industry sector.

Sustainable development is a major concern as countries attempt to implement strategies to reduce greenhouse gas emissions. This involves reducing environmental pollution and the use of resources, eventually contributing to the welfare of society, i.e., to the improvement of the social conditions of the population. Sustainable development relies on the contribution each country worldwide. This encourages creative thinking in putting forward strategies and in the planning and development of cities and communities. The idea of sustainable development materialized at the Rio summit. Agenda 21 was established in Rio in 1992, which integrates the principles and imperatives worldwide for sustainable development (United Nations Conference on Environment and Development—UNCED, 2014). As shown by Häikiö, sustainable development implies the idea of a situation/world which is better than the current one, the direction towards a society based on reuse and reduction (Häikiö, 2014).

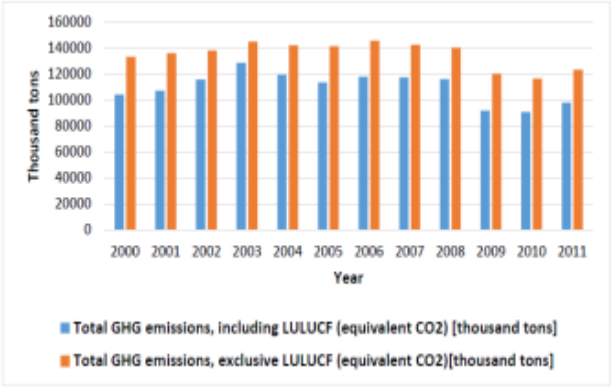
Because there is a need to develop a benchmark for assessing sustainable development, the European Commission substantiates the requirements of this concept. In 2000, the European Commission launched the tool of "triple base line" based on the requirements of sustainable development (European Commission. 2013).

In the context of real energy challenges, both in terms of sustainable use of resources and emissions of CO_2 and the security of energy supply, Romania has achieved a balance in this regard. Climate change affects all of Europe, with a wide range of effects on society and the environment. Other impacts are expected in the future that may lead to significant damage,

according to the most recent estimates published by the European Environment Agency. "Climate changes are a reality throughout the world, and their scale and rapidity are becoming more evident. This means that each component of the economy, including households, must adapt and reduce emissions - Jacqueline McGlade (Executive Director of the European Environment Agency)" (McGlade, 2012).

Extreme weather phenomena in most regions, such as climate change, heat waves, flooding and droughts have triggered, in recent years, increased environmental damage throughout Europe. Although more evidence is required to discern the role of anthropic activities in climate change, increasing human activity in areas prone to hazards has been a key factor. It is expected that future climate change will increase this vulnerability because extreme weather events may become more intense and frequent. Romania's National Strategy on Climate Change 2013–2020 (SNSC) aims at reducing emissions of greenhouse gases and adapting to the inevitable negative effects of climate change on natural and anthropic systems. Greenhouse gas emissions are those stipulated in the Kyoto Protocol of the six gases responsible for the greenhouse effect. This indicator measures the greenhouse gas emissions: carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4) and three halocarbons (hydrofluorocarbons-HFCs, perfluorocarbons-PFCs, Sulphur hexafluoride-SF_6) measured by the global warming potential (Varga, 2013). Of all the items on the list, CO_2 is considered to be the most significant contributor to climate change. Each of the six gases listed above has its own global warming potential based on its radioactive capacity compared to CO_2. Second and third, in terms of importance, are CH_4 and N_2O with a considerable contribution to global warming and environmental change.

Figure 1.84 (a) shows the total emissions of greenhouse gases in Romania, including land use, land-use change and forestry (LULUCF), CO_2 equivalent, and the total emission of greenhouse gases, but excluding LULUCF CO_2 equivalent between 2000 and 2011. The analysis of these values shows that the total GHG emission level has had a downward evolution since 2006 in Romania, which has been an improvement. Figure 1.84 (b) shows the situation of Romania's GHG emission by sector of activity. The energy sector is thus developing the largest quantity of GHG per year, with a slight decrease since 2006. In Romania, the data related to the years 2000–2011 are presented by the National Institute of Statistics (NIS). For the years 2012–2014, NIS does not present the data on GHG emissions.



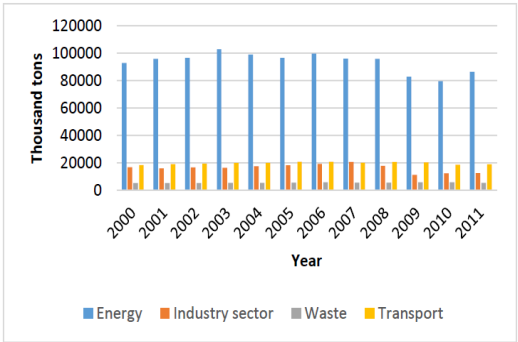


Figure 1.84. (a) Total greenhouse gas (GHG) emission including Land use, Land Use Change and Forestry (LULUCF) and exclusive LULUCF in Romania. (b) GHG emission by sector of activity in Romania (in thousand tons)

Source: National Institute of Statistics, 2014

This study is based on the systematization of information on the directives of the European Commission concerning the reduction in the use of natural resources, the processing of sets of relevant statistical indicators, and the analysis and identification of solutions suitable to mitigate the impact of these carbon dioxide emissions through use of renewable resources. Figure 1b shows that GHG started to decline in 2009 because all organizations in all activity sectors began using renewable resources and began to take on board the concept of sustainable development. The emission level decreased as a result of economic instability which had impacted transport, various branches of production and other related activities. Romania was also affected by economic instability. Since 2011, Romania has experienced economic growth, with an increase in labour productivity/employment (a growth rate of 7.1% in 2006, 5.9% in 2007, 5.3% in 2008, and decreased rate of 4.7% in 2009, 0.9% in 2010 and a growth rate of 2.9% in 2011). The Romanian Government supports the use of renewable sources through several legal norms: the green certificates system (the producer receives from the national energy organization a number of free green certificates for the energy it produces and delivers to the network) and the subsidies granted to the producers and users of renewable sources. This sustainable behaviour in Romania is aligned with EU requirements on the use of renewable resources (National Institute of Statistics. 2014).

CO_2 Emissions in Romania and the EU Today

Scientific studies show that the greatest amount of CO_2 emissions, in the European Union, results from the production of electricity and heat (for example, the production of coal-based energy in the EU Member States generated approximately 950 million tons of CO_2 emissions in 2005, equivalent to 24% of total CO_2 emissions in the EU). Cities and urban agglomerations in each country have an essential role to play in mitigating climate change, given the fact that they consume three-quarters of the energy produced in the EU and are responsible for a similar percentage of CO_2 emissions (International Energy Agency, 2014; Regional Development Agency, 2014).

Under the Kyoto Protocol, Romania was obligated to reduce emissions of greenhouse gases by 8% between 2008 and 2012 as compared with 1989. Romania's objective is to double its energy production to about 100 TWh before 2020. Moreover, there also exists the International Municipalities Convention signed by 6160 cities (Covenant of Mayors, 2014). This Convention is one of the most important European actions involving regional and local authorities that commit themselves voluntarily to increase energy efficiency and the use of renewable energy sources in their territories. Through their commitment, signatories of the Convention aim at achieving and surpassing the EU objective of reducing CO_2 emissions by 20% before 2020, in every city which adhered to the Convention. In Romania, 83 towns/cities from a total of 320 cities have acceded to this Convention. Across Europe there are 6149 signatories and 11 signatories in Asia. Romania is constantly trying to reduce environmental pollution by reducing

greenhouse gas emissions. The political commitment assumed by signing the Covenant of Mayors is transposed into the development of directions and strategies for attaining the 20% reduction in CO_2 emissions, and the use of renewable energy sources.

By analysing the amount of CO_2 in the European Union, it was found that the transportation sector is the second heaviest polluter, after the electrical and thermal energy sector. The graphical representation is showed in Figure 1.85 (a) for the situation in the European Union and in Figure 1.85 (b) for the situation in Romania. As shown in Figure 1.85, Romania's situation has improved by 1.2%, as progress has been made in reducing emissions from the transportation sector. This improvement was the effect of introducing an expensive tax for cars non-compliant with the Euro4 emission standard (the Euro4 emission standard specifies a maximum limit of 25 mg/kg particulate matters (PM) and 250 mg/kg of nitrogen oxides (NOx)). Thus, the population shifted their preference towards vehicles compliant with the Euro5 and Euro6 standards. The rules related to the pollution standard are set by the regulation of the European Parliament and Council on the approval of road vehicles. The Euro5 emission standard requires reducing emissions by 80% compared to the Euro4 emission standard, allowing 5 mg/km of PM and 160–180 mg/km of NOx. The Euro6 emission standard reduces the values of PM and NOx, in comparison with Euro5, to 1 mg/km of PM and 40 mg/km of NOx.

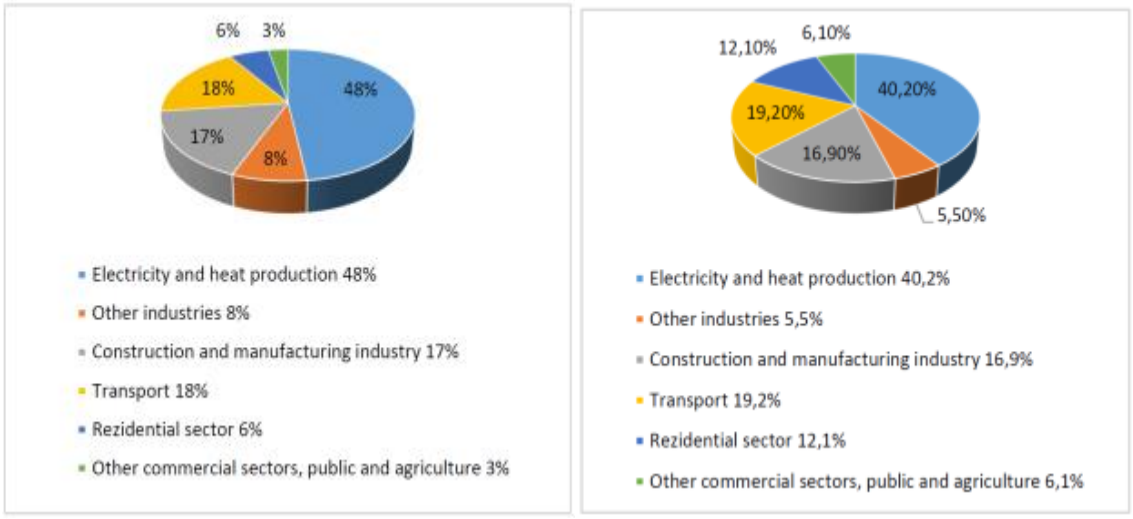


Figure 1.85. (a) The CO_2 emissions of different business sectors in the EU. (b) The CO_2 emissions of different business sectors in Romania.

Figure 1.85 (a), (b) shows that CO_2 emissions are produced mainly by electricity and heat production, transportation, and the industrial sector. For each sector, the situation in Romania is presented and the renewable resources that can be used to alleviate the current situation are evaluated. The waste sector is also represented as well as Romania's involvement in recycling waste in comparison with the EU.

The Energy Sector

The energy sector is the basis of development of a country as part of the economic infrastructure. In the current context, sustainable development involves meeting the energy

demand, not by increasing energy supply (except for the provision of renewable energy), but through reducing energy consumption by improving technologies, by restructuring the economy and by changing attitudes concerning the efficient use of energy. The intensity of CO_2 emissions between 2000 and 2011 is shown in Figure 1.86. The intensity value for each year was calculated as the ratio between CO_2 emissions from energy consumption in the year and the Gross Domestic Product (GDP) in that year.

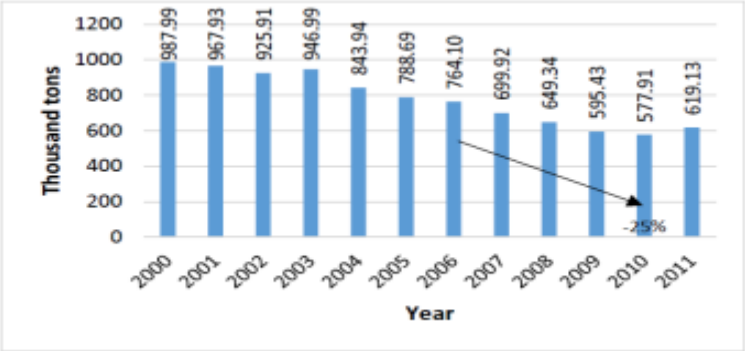


Figure 1.86. CO_2 emission intensity of energy in Romania between 2000 and 2011

According to Figure 1.86, the reduction of CO_2 impact on the environment for the energy sector was achieved through the use of renewable energy sources (RES). These sources include forms of energy derived from renewable, natural processes, in which the production cycle takes place in periods that are directly proportional to their consumption periods. Thus, the energy of sunlight, winds, flowing water, biomass and geothermal heat may be captured by using different technologies (Duflou et al., 2012; Yuan et al., 2012; MoosaviRad et al., 2014; Paska, and Surma, 2014. Renewable energy is extremely important today, being considered to play a crucial role in increasing the security of energy resources by reducing dependence on fossil fuels and reducing greenhouse gas emissions. Several researchers have focused on the analysis of renewable energy resources in the European Union (Swider et al., 2008; Ostergaard, 2009; Lund, and Mathiesen, 2009; Ban et al., 2013; Gaigalis et al., 2014). The proposed RES measures have brought considerable improvement, but have not shown evidence of full involvement in sustainable development.

The consumption of energy from RES in the year 2011 and target in 2020 for Romania and for EU-29 (European Union with 27 members plus Switzerland and Norway) is shown in Figure 1.87. In 2011, the RES share in the final energy consumption of the EU was 13.0% compared to 8.5% in 2005 (European Commission. Europe 2020 Indicators—Climate Change and Energy, 2014).

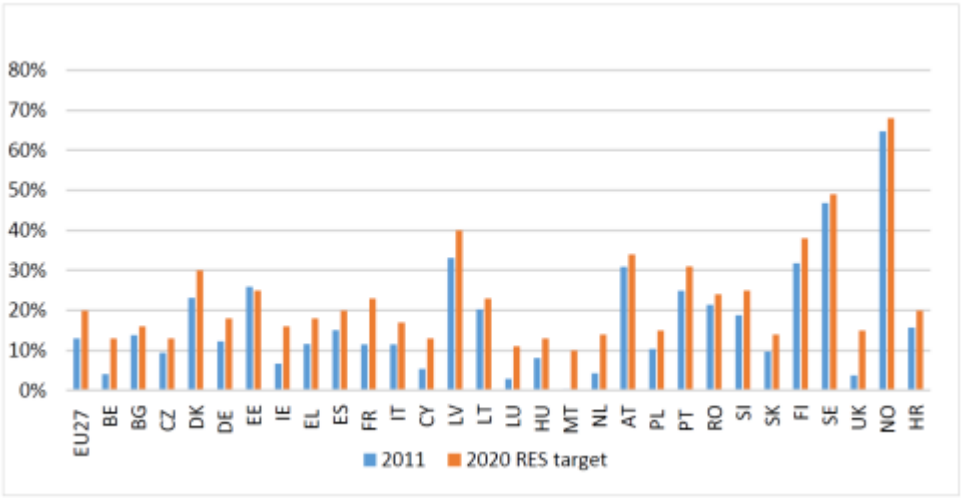


Figure 1.87. Member States progress towards 2020 targets in renewable energy, %

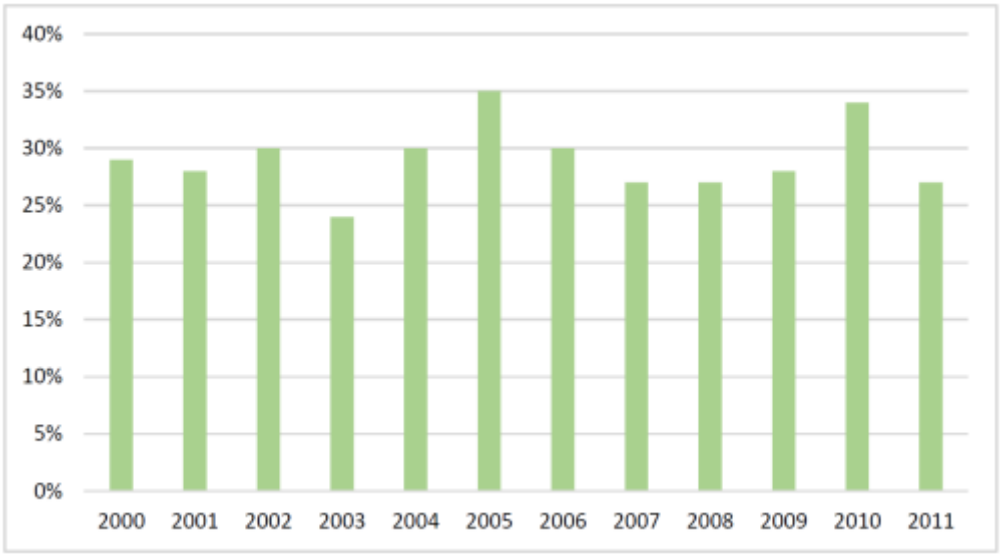


Figure 1.88. Share of electricity from renewable sources of total electric power

Source: Eurostat, 2014.

In recent years, the production of renewable energy has shifted from being viewed as a possible alternative into an obligatory alternative. Romania's potential in relation to renewable energy resources in the total electrical energy is shown in Figure 1.88 (Eurostat, 2014). Renewable energy sources taken into consideration in this analysis are: bioenergy, geothermal energy, wind energy and solar energy. It show a decrease of about 7% in 2011 compared to 2010 as wind and solar power intensity decreased. As shown in Figure 1.88, the year 2006 was less favourable to hydropower production, because it was drier than 2005. The low rainfall in the coming years led to a decrease in the yearly energy production from renewable sources.

In terms of solar radiation in Romania, the monthly spread of the values on the Romanian territory reaches maximum values in June (1.49 kWh m^{-2} d^{-1}) and minimum values in February (0.34 kWh m^{-2} d^{-1}). Most solar-thermal systems are made with flat or vacuum-tube solar

collectors, especially in areas with low solar radiation in Europe. In the national strategy on the use of renewable energy sources, the stated wind potential is 14,000 MW (installed capacity), which can provide a quantity of energy of approximately 23,000 GWh y^1. These values are an estimate of the achievable potential. With respect to the energy potential of the biomass, the Romanian territory was divided into eight regions, accumulating in the year 2011 around 3.618 million tonnes, thus having the largest share of the total renewable energy resources in Romania. Water resources of developed inland rivers are valued at about 42 billion cubic metres per year, but because they are undeveloped, Romania can rely on having approximately 19 million m^3/y due to fluctuations in the flow of rivers. The synthesis of the achievable RES potential of Romania is analysed in Table 1.66 (Dusmanescu et al., 2014). For "tonne" we have used the abbreviation "toe" throughout the entire section.

Table 1.66. Potential of Romania for renewable energy sources.

Renewable Energy Source	Technical Potential [GWh]	Technical Potential [thousand toe]
Wind	409,731	35,231
Solar thermal	14,932	1,284
Solar photovoltaic	161,929	13,923
Biodiesel	6,084	523
Bioethanol	45,461	3,909
Solid fuel	71,966	6,188
Micro hydro	14,724	1,266
Geothermal	279	24
Total	710,103	61,058

The Transportation Sector

Rules and policies in energy and the environment highlight the considerable environmental impact of urban agglomerations and increase in the number of motor vehicles. According to the latest studies, urban traffic generates 40% of CO_2 emissions and 70% of other pollutant emissions (Park et al., 2014; Rada, 2014; Kheirbek et al., 2014; Istrate et al., 2014; Ryu et al., 2015) .

At the EU level, transportation is responsible for about 28% of GHG emissions, and 84% of these are caused by road transport. The high level of emissions from road transport (CO_2, CO, NO_x, SO_2, NH_3, and volatile organic compounds, particles loaded with heavy metals, *i.e.*, lead, cadmium, copper, chromium, nickel, selenium, and zinc) has a considerable effect on the environment, human health and on local and national sustainable development.

Eurostat highlights that, between 2011 and 2012, CO_2 emissions decreased in nearly all Member States, except Malta (+6.3%), the United Kingdom (+3.9%), Lithuania (+1.7%) and Germany (+0.9%). The most significant decreases were those in Belgium and Finland (both

−11.8%), Sweden (−10.1%), Denmark (−9.4%), Cyprus (−8.5%), Bulgaria (−6.9%), Slovakia (−6.5%), the Czech Republic (−5.2%), Italy and Poland (both −5.1%).

In Romania, in 2010, there were 32,897 (thousand tons CO_2) going down in 2012 and reaching 30,758 (thousand tons of CO_2). Thus, there is an improvement of 6.5%, *i.e.*, a decrease in CO_2 emissions of 2,140 (thousand tons CO_2). This CO_2 decrease is due primarily to the legislative environment by introducing the environment tax for aggressive polluting cars and due to investments in educating people about the use of renewable resources at an industrial and domestic level (by total or partial funding of using these emerging technologies). EU reports that, in terms of fuel consumption, the 2015 target is approximately equivalent to 5.6 litres per 100 km of petrol or 4.9 litres per 100 km of diesel. The 2021 target equates approximately to 4.1 of petrol or 3.6 l/100 of diesel litres per 100 km (Eurostat Statistics, 2014).

Transport systems used in Romania are freight and passenger transport. Within these systems, the following networks operate: road transport, rail transport (maritime and inland waterways), air transport, non-motorized and special (through pipes and electric air transport).

Energy consumption for every mode of transport in Romania is shown in Figure 1.89 (National Institute of Statistics, 2014). Thus, road transport has the greatest share, around 89% of the total energy consumption in transportation, in 2011.

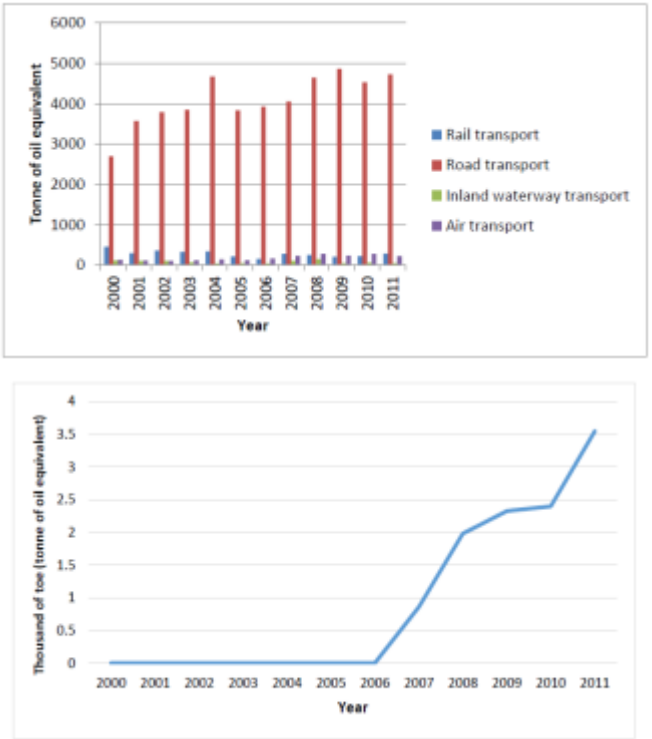


Figure 1.89. (a) Energy consumption by transport mode (national/modes of transport/1,000toe). (b) Biofuel consumption in the transport sector (%/national/1,000toe)

Source: National Institute of Statistics, 2014.

To improve the current situation, efforts are being made for reducing the number of and retiring the old, highly-polluting vehicles from the roads and for developing strategies to encourage the population to purchase hybrid cars.

As seen from the evolution presented in Figure 1.89, steps are being taken to support the use of bio-fuels and hybrid cars in transportation, which lead to a value of 3.55% in 2011 as shown in Figure 6b. The European Union Directive 2003/30/EC presents the objective of reaching a 5.75% share of renewable energy as a proportion of the total energy consumption of the transport sector by 2010 (Fujii et al., 2014).

It should also be mentioned - even though it is not within the scope of this section - it has been argued that the 2030s will bring about transport technologies (with low or zero emissions) that will be implemented on a large scale, and the following decade (the 2040s) will call on major and complex decisions to be made on energy technologies and on the structure of the EU economies.

The Waste Sector

Good waste management based on waste selective collection and recycling can decrease the carbon dioxide (Panepinto, and Genon, 2012; Ionescu, and Stefani, 2014; Rada et al., 2014). In Romania, the municipal solid waste (MSW) recycling rate reached its highest value in 2011, *i.e.*, 7% of the total collected waste. The evolution of MSW collection and recycling are shown in Table 1.67. The quantity of MSW collected per capita, in the year 2011, in Romania was 239 kg, 22% less than in 2008. In Romania, waste is mostly stored in locations specifically designated for this operation, but which are not managed properly. However, some pilot experiences on composting, thermal treatment or co-combustion of some fraction of MSW as they are or pre-treated were developed or are in progress (Negoi et al., 2009; Ghinea et al., 2012; Government of Romania—Ministry of Foreign Affairs, 2013)

Table 1.67.Municipal waste collection and recycling rate

MSW (tons)	2006	2007	2008	2009	2010	2011
Collected	6,334,491	6,187,943	6,558,342	6,264,778	5,325,808	4,553,300
Recycled	40,945	65,741	72,110	100,455	296,342	331,622
MSW recycling rate	0.65%	1.06%	1.10%	2%	6%	7%

Source: National Institute of Statistics, 2014.

The Industrial Sector

The industrial sector is a major polluter in Romania, among the top three sectors that emit CO_2 into the atmosphere, contributing to environmental pollution. In Romania, according to public reports, in 2010, there were 491,805 active companies, significantly less than in 2008 (Figure 1.90 (a)). Currently, the number of active companies is in a slight decline, which is the main cause of the reduction of waste generated by economic activity. In the current situation of economic instability, there is a downward evolution in the number of active companies as

reported by the national statistics (National Institute of Statistics, 2014). The first waste generator is mining, but the quantity has decreased since 2007 (Figure 1.90 (b)).

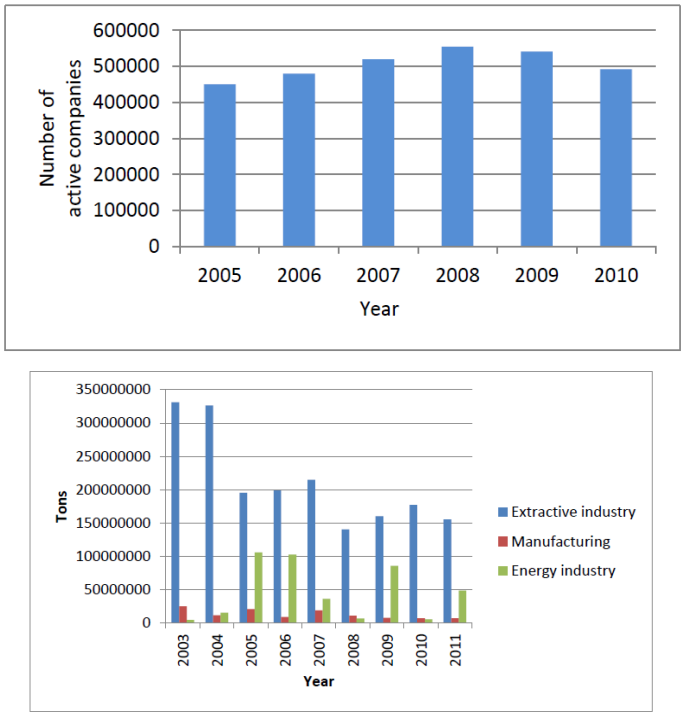


Figure 1.90. (a) Romanian active companies (b) Generated waste by economic activity (tons).

Results and Discussion

The above data may be useful in performing an assessment of the trends in the use of renewable resources in Europe and Romania. Thus, in the EU, considerable increase in the use of RES is expected, in order to mitigate the environmental impact of greenhouse gases, and in particular of carbon dioxide.

Figure 1.91 shows the evolution of RES in the analysed sectors in accordance with EU strategies: renewable energy sources for electricity (RES-E), renewable energy sources for heating and cooling (RES-H&C), renewable energy sources for transport (RES-T), renewable energy sources for industry (RES-I) and renewable energy sources for residential (RES-R). RES-E is clearly the most important with an expected value of 50% until 2050 and an increase of 35% until 2020 (Vadim et al., 2013). Assessing Romania in terms of the use of RES and the alignment with the EU strategies and policies, the situation is shown in Figure 1.91.

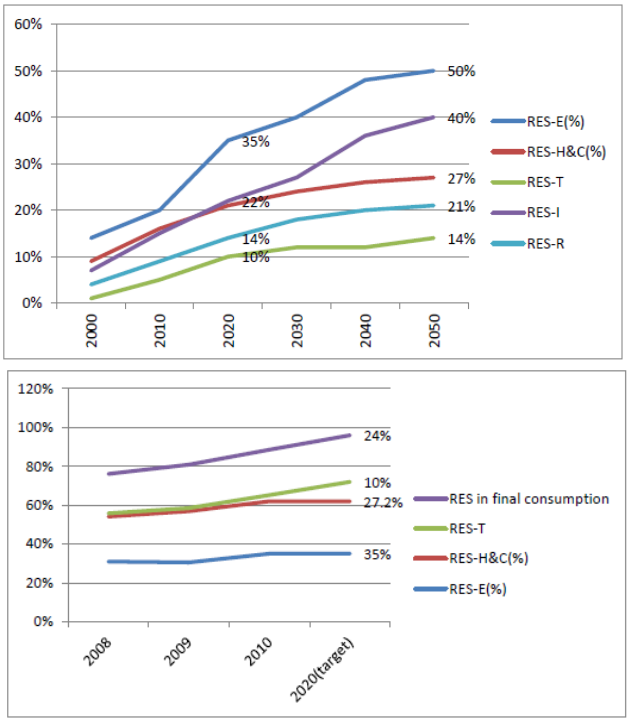


Figure 1.91. (a) Renewable energy resources (RES) indicators at the EU level. (b) RES indicators at the Romanian level.

Analysed data related to GHG emissions proves that there will be a difference of at least 50 million tons of CO_2 equivalent annually, as difference between the target value laid down in the Kyoto Protocol and the total emissions in the commitment period of the 2020 convention, even considering the possible uncertainties related to inventories and projections of GHG emissions. The economic crisis of the recent years has reduced these levels even further. The total GHG emissions of Romania in 1990 were 253.3 (million tons), being reduced by 52.1% in 2010, *i.e.*, 121.4 (million tons) (Eurostat, 2014).

According to the Kyoto Protocol, average 2008–2011 emissions in Romania were 53% lower than the base-year level, well below the Kyoto target of −8% for the period 2008–2012. LULUCF activities are expected to decrease net emissions by an annual amount equivalent to 1.1% of base-year level emissions.

In the second part of this section, Romania's carbon footprint is to be shown. Thus, CO_2 emissions in Romania highlights the environmental impacts associated with energy use in various sectors of activity listed at the beginning of this study. The total CO_2 emissions in Romania is divided by the total number of citizens and the thus the carbon footprint indicator is obtained; it represents virtually the total amount of greenhouse gases (expressed in CO_2) we produce per year through the burning of fossil fuels for heat or electricity we consume, as shown in Figure 1.92.

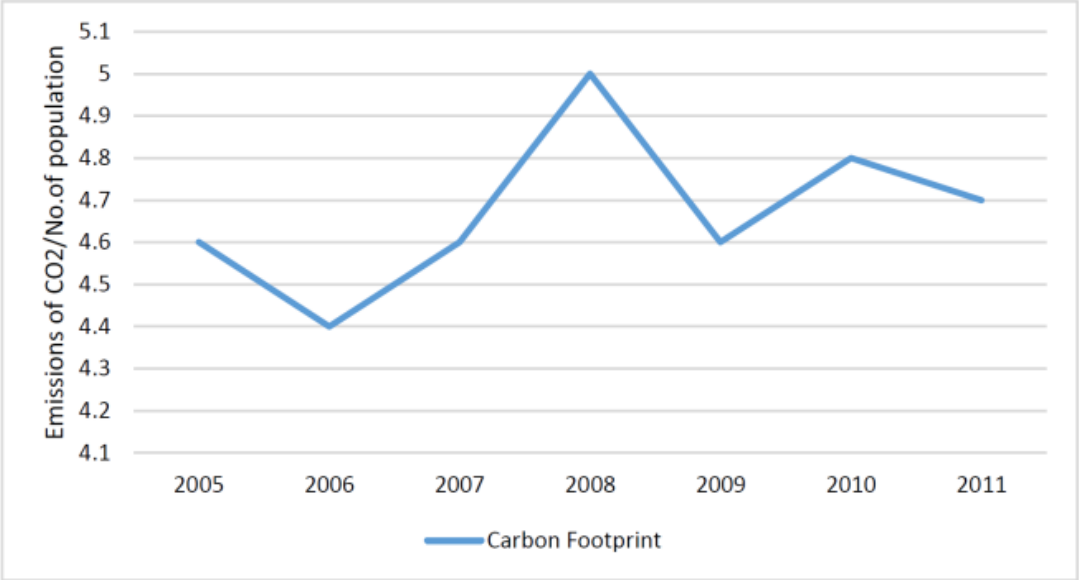


Figure 1.92. Carbon Footprint

A Summary of Findings

A number of considerations may be made on the basis of available data, starting from the situation of Romania's in comparison with that of the EU and considering the participation in the Kyoto Protocol and the Covenant of Mayors-EU:

- Level of total GHG emissions is lower compared to 2008, but there was a small increase in 2011;
- The emissions decreased mainly in public electricity and heat production and road transport;
- In terms of the CO2 emissions in Romania, there are actions to monitor and reduce pollution in excessively polluting sectors (the first three sectors): electricity and heat production, manufacturing industry and transport. For example, Romania's energy sector emits 8% more CO2, *i.e.*, 48%. These actions and strategies mainly refer to the use of renewable sources (subsidized by the government) and to the reduction of polluting factors and their replacement with innovative elements;
- Due to the intensity of rainfall and climate change, the share of electricity from renewable sources of the total electric sector was 27% in 2011, *i.e.*, a lower value than in 2010 when it was 34%;
- In terms of transport, both in Romania and the EU, road transport has the largest share of modes of transport. It consumes the greatest amount of energy, surpassing by far air, rail or inland waterway transport;
- There are efforts to use bio-fuels and hybrid cars in transportation, reaching a value of 3.55% in 2011, which was a major breakthrough compared to 2006;
- The waste sector is in an unacceptable situation in comparison with the EU. The expected reduction of landfilling will positively affect the role of MSW sector in the balances of GHG thanks to the decrease of fugitive emissions of methane;

- Romania is situated below the EU per capita average amount of MSW generation;
- The industrial sector shows a slight decrease in the number of active companies, and thus there was a slight decrease in the amount of waste generated.

Considering the above, Romania is making substantial efforts to reduce CO_2 emissions by adopting nationwide the necessary directions and strategies (for example, subsidies granted to producers of renewable energy, reducing national taxes for cars that do not pollute excessively, by purchasing vehicles for public transport that run on renewable energy, and others), thus aligning to European directions for the use of renewable energy and adoption of effective waste management policies.

Conclusions

The effectiveness of resources must be examined in the context of sustainable development. There is a strong connection between the quality of life and the way countries manage their natural available resources. Resource-efficient countries have a higher degree of innovation, productivity at lower cost and low impact on the environment, while providing multiple opportunities for improving emissions and sustainable life styles. Therefore, the efficient use of resources is based on a number of factors, such as redefining the way in which urban systems are globally understood, developing a common language for the assessment of sustainability indicators, reviewing the indicators which constitute the sustainability of cities and the financial support of the entities.

The main greenhouse gas produced by human activities is carbon dioxide (CO_2). It represents over 80% of the total emissions of greenhouse gases in EU Member States. The presentation of Romania's situation globally represented the starting point for future research: evaluation of CO_2 emissions for each mode of transport, the investigation of waste management technologies and their impact on Romania, the assessment of the types of industries and amounts of greenhouse gas emissions and the modelling of renewable resources at a national level.

1.5.2. The importance of waste management for improving environmental conditions

Sustainable development has become a central element in the work of national and international companies. From this perspective the focus is more and more on protecting the environment and society. So, waste management is a sensitive area for organizations. The section presents the situation of municipal solid waste management (MSW) in Romania, relative to EU requirements. Optimization of waste collection through source separation is mandatory, while the management based on waste land filling must be overcome. In this section some aspects are analyzed, related to the technologies used and the amounts collected in relation to the EU.

In the context of sustainable development, waste management is an activity that shapes the environmental protection. Sustainability has become the model of development adopted at international level, whereby both organizations and people act in accordance with the principles

and its amendments. Since 1951 when the International Union for the Nature Conservation published the first report of a state on the global environment that is seeking reconciliation between economy and ecology and until present, the concept of sustainable development was shaped by the various interpretations. Currently, according to a study (Ivascu et al., 2014) most organizations associate sustainable development with environmental protection and with actions related to society. Environmental concerns are still intense. Organizations and municipalities develop intensive activities in this direction. At the beginning, emphasis was placed on selective waste collection (Brunner et al., 2015), currently there is intense concern for waste management and recycling. Human activities and those of organizations inevitably produce waste (Moraru et al., 2010). As analyzed territory is bigger the challenge of waste management is more complex (Lavee, 2007). Together with measures to reduce waste, waste management contributes significantly to the achievement of sustainable development.

Waste management in Romania

Sustainable development is dealt with extensively in Romania. In a survey conducted in Romania, it was observed that most organizations (78.4%) associated sustainable development with activities for environmental protection, and 85.7% of these organizations are involved in social activities. Within this research there were involved 95 companies from Romania from the categories: micro (11), small (15), medium enterprises (34), large enterprises (27), and very large enterprises (8). The classification of the enterprise's size class was conducted in accordance with Law No. 346/2004, regarding the stimulation, the creation and growth of SMEs, as supplemented and amended, which establishes criteria for classifying enterprises (Official Gazette). Companies that exceed a category, in terms of number of employees, turnover or total assets are classified in the upper category when there is observed at least one of these limits.

The present research integrates elements of sustainability, risk assessment and international standards. The author approach sustainable development in the four responsibilities of sustainability through their integration in the economic environment, with direct impact on the company. The study results are summarized in Table 1.68.

Table 1.68. Centralization of the data

Type	The implication of question	Affirmation answer
Risk	The existence of risk manager	63.3 %
	Risk monitoring	96.7 %
	Implementation of a tool	32.7 %
Standardization	Implementation of ISO 9000	96.3 %
	Implementation of ISO 14000	77.8 %
	Implementation of OSHAS18000	28.5 %

	Implementation of ISO 26000	7.4 %
	Implementation of ISO 27000	22.2 %
	Implementation of ISO 31000	42.6 %
Sustainability	The importance sustainable development	60.7 %
	Actions to protect the environment	78.4 %
	Social action	85.7 %
	Responsible programming of waste management	31 %
	Selective waste collection	65%
	Selective Technologies	7%

It is noted that a substantial fraction of the surveyed enterprises addresses the implications of sustainable development. Also, in most cases there was an overlap of the concept of sustainable development with environmental protection actions. Therefore, the organizations do not differentiate, yet strict environmental implications compared to the complexity of sustainable development of the enterprise (Mihaescu et al., 2008).

Waste management

In Romania, the policy on waste management (WM) must subscribe to European policy objectives relating to waste prevention and aims to reduce resource consumption and practical application of the waste hierarchy. In 2010, the EU member states produced over 252 million tons of MSW. This amount is representing around 502 kg per capita (Cruz et al., 2014). WM approach in EU (European Commission-Environment) is on three major directions:

- Waste prevention - an important factor in the development of national strategies directly related to production methods of organizations and lifestyle approach which should generate lower amounts of waste;
- Recycling and reuse - encouraging the recovery of a high level of material components, in particular by recycling materials.
- Improving final disposal and control of waste - in case the waste cannot be recovered, it must be removed in optimum conditions for environment and society health.

Actions for waste management are present in most organizations. For example, in the study (in a city representative of Romania) on 457 educational institutions (pre-schools, primary and secondary schools, high schools, special schools) it is shaping the image of waste management at educational level. Most of the educational institutions (63.90%) practice a daily waste collection from class rooms, while 30.24% prefer to collect once in two days. The rest of the institutions practice a more frequent collection (twice a day or during every break time).

In Romania (National Institute of Statistics), municipal waste collected per capita for the period 2003-2011 are shown in Figure 1.93. It is noted that in 2005 we generated the largest quantity

of waste, namely 6,558,363 tons, followed by year the 2008 with 6,558,342 tons. Since 2008, the amount of waste considerably began to decline, reaching in 2011 4,553,300 tons. Further data after this year (2011) are not available online on the website of the National Institute of Statistics.

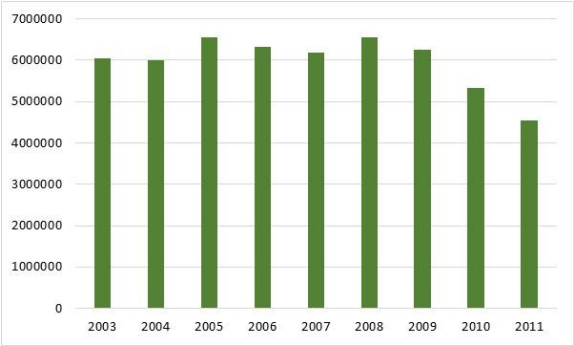


Figure 1.93. Collected municipal waste (tons)

The distribution of the amount of waste per capita in Romania is presented in Table 1.69. The maximum amount of waste generated per capita is registered in 2008 and the smallest amount in 2011. It is noted that the proportion is maintained even if the number of inhabitants is taken into considered.

Table 1.69. Collected municipal waste per inhabitant

Indicator	2003	2004	2005	2006	2007	2008	2009	2010	2011
Quantity (tons)	6040230	6001200	6558363	6334491	6187943	6558342	6264778	5325808	4553300
Population (1st January)	21772774	21711252	21658528	21610213	21565119	21528627	21498616	21462186	19042936
Quatity/inhabitant(kg)	277	276	303	293	287	305	291	248	239

Source: National Institute of Statistics, 2011

Municipal waste recycling rate is presented in Table 1.70. The industrial sector is the major element that generates waste in Romania and most polluting industry is mining (Cioca et al., 2015)

Table 1.70. Municipal solid waste collection and recycling rate

MSW (tons)	2006	2007	2008	2009	2010	2011
Collected	6,334,491	6,187,943	6,558,342	6,264,778	5,325,808	4,553,300
Recycled	40,945	65,741	72,110	100,455	296,342	331,622
MSW recycling rate	0.65%	1.06%	1.10%	2%	6%	7%

Technologies used in Waste management in Romania

At EU level, the generation of MSW has increased in parallel to the rapid industrialization, where the waste amount has recently grown with approximately 11% in 12 years and is expected to grow with 45% by 2020 (Ionescu et al., 2013). For this reason the technologies used in waste management must evolve with advanced technological support. In Romania there

have been considerable efforts and significant investments were made to align with EU requirements, but the main way of waste disposing presently is storage. This action can be improved by the use of geographic information systems (GIS). There were developed a number of applications using GIS for different areas (Esmaili, 1972; Ghose et al., 2006; Karadimas et al., 2007). Among these applications, the study of complex systems of waste management, particularly placement waste management and disposal facilities was preferred direction for GIS applications. Currently, at international level, integrated GIS technology has been recognized as one of the most appropriate approach to automate planning and waste management (Karadimas et al., 2008). A tool that can be used in this process is Geographic Resources Analysis Support System (GRASS). In Romania, according to the Eurostat report (Eurostat, 2013), 99% of municipal waste collected is stored, and 1% are recycled. For this reason, the identification of suitable areas for waste storage using GIS technology represents a significant support in the direction of sustainable development of the country.

Result and discussions

Following the above analysis it can be concluded that in Romania MSW presents improvements, and is a priority in national development strategy. In outlining the strategy on waste management the following actions should be considered to achieve the objectives:

- The use of "clean technologies" in waste generating activities;
- Reduction / prevention of waste quantities by applying best practices for each field in which waste is generated;
- Capitalization through recycling, reuse and energy recovery;
- Elimination through landfills and incineration.

Waste Management properly adopted is a key element in ensuring an efficient use of resources and sustainable development of Romania. To fulfill the European objective, Romania has to make considerable efforts to increase the recycling rate. It will require an exceptional effort from regional and national authorities in Romania in order to increase recycling to 50% by 2020, as required by the European Commission.

The evolution of Information Technology sector shows a decrease in costs and an improvement of the indicators relative to pollution. Certainly, the structural funds are a cornerstone in improving the situation in Romania and optimization of MSW. The analysis of the situation in Romania shows that the MSW has evolved, but this area is still faced with problems that can be addressed through well implemented strategies.

1.5.3. Challenges and opportunities associated with waste recycling development in Romania

European Union (EU) policies are regularly targeting a number of actions on reducing municipal waste and increasing its recycling rate. From this perspective, the situation in Romania is not a favourable one and requires measures for improvement. The recycling rate of Romania is well below the EU average. For Romania, in 2017, the recycling rate was 14.5%, and at for the EU it was 46.9%. This part aims to assess Romania's capacity to increase its

recycling rate. It also presents the EU situation. At the end of the evaluation, a conceptual framework of challenges and opportunities is proposed in order to reach the EU objective of recycling policies.

The UN's 2030 Agenda for Sustainable Development offers a new global framework that contributes to poverty reduction, combating inequalities and combating climate change. Sustainable development also takes into account occupational hazards (Babut and Moraru, 2018). The agenda includes 17 objectives and their related 169 targets. Since 1990, the EU has introduced policies and targets on waste. These include a series of strategies that pursue the goals of sustainable development. Since 2005, the Thematic Strategy on the Prevention and Recycling of Waste (EC, 2017) and framework legislation such as the Waste Framework Directive (EC, 2017) sets the target for 50% of municipal waste to be prepared for reuse and recycled in EU member states. In 2015, the European Commission publishes the document "Closing the Loop - An EU action plan for the circular economy (EC, 2017) (or Circular Economy Package)". This document sets out a number of new objectives. A first objective is to reach the recycling rate of 55% by 2025. Municipal waste includes household waste and other refuse, which, by nature or composition, are similar to household waste (Ministry of Environment, GD no 349/2005, 2017).

Waste is a major problem in Romania. The country's waste generation rate is on the rise. This increase is due to the degree of urbanization, industrialization and population behavior. Faulty waste management can cause adverse effects on the environment, risk to public health, excessive environmental pollution and other economic and social problems. In EU, waste management shows an improved situation, superior to the situation in Romania. There are a number of regulations and norms that guide EU member states in enhancing waste management (NIS, 2018).

The Environment Committee within the European Parliament approved this year a set of new regulations which oblige EU member states to increase the recycling percentage and encourage producers and consumers to reuse valuable materials imbedded in wastes. This new set of rules establish legally mandatory targets for waste recycling and the reduction of land filling that have fixed deadlines (Antonopoulos et al., 2014).

Waste management: system quality and new EU rules

In Europe, the amount of municipal waste that is recycled has steadily increased as a result of investment in the collection, proper handling of financial incentives to move away from waste disposal and the banning of landfills in the member states. The performance of EU member states with regard to municipal waste recycling varies, due to multiple factors (economic power, technological innovation capacity, population density and so on). The Circular Economy Package (EC, 2017) contains a number of objectives and measures to be achieved. Among these are:

- Increase the recycling and reuse rate to 65% by 2030 for municipal waste;
- Increase recycling and reuse rate to 75% by 2030 for packaging waste;
- Reduction of landfills up to 10% of municipal waste by 2030;

- Prohibiting the storage of separately collected waste;
- Promoting and implementing economic instruments to deter storage at the level of each country;
- Develop simplified definitions and harmonized calculation methods for recycling rates for all EU member countries;
- Promoting the principles of the circular economy by developing concrete measures to promote the re-use and stimulation of industrial symbiosis - transforming the by-product of an industry into a raw material;
- Launching incentives for producers. Manufacturers should market organic products and support recovery and recycling systems (e.g. packaging, batteries, electrical and electronic equipment and vehicles).

In EU, the targets set by "Closing the loop — An EU action plan for the circular economy" on increasing the recycling rate are being pursued. "Waste recycling is defined as any recovery operation by which the waste is reprocessed in products, materials or substances, either for original purposes or for other purposes. This includes reprocessing of organic materials (e.g. by composting or digestion), but does not include the recovery and recycling of energy in materials to be used as fuels or for filling operations "(EC, 2017). The quantity of waste generated in the EU in the period 2012-2017 is presented in Figure 1.94. The amount of waste is increasing, hence the objectives.

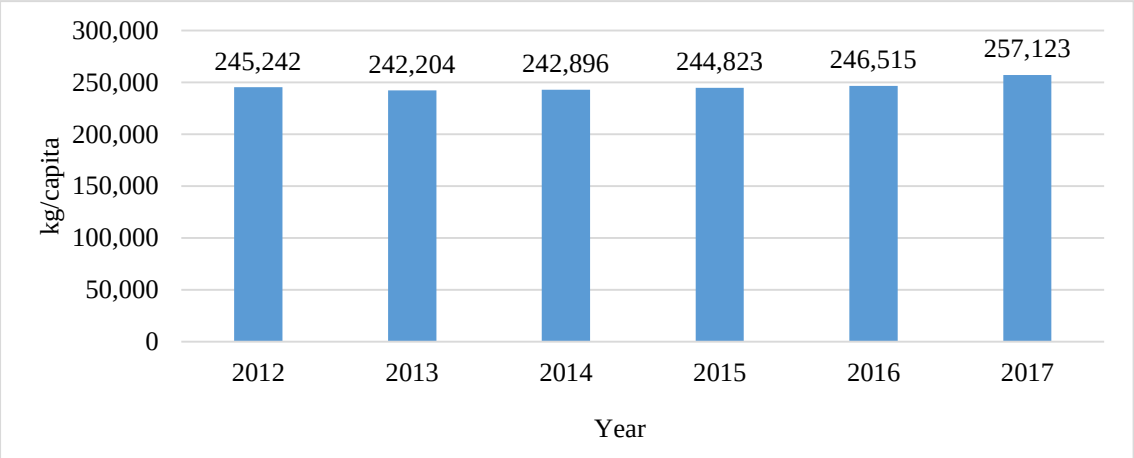


Figure 1.94. The amount of waste generated per capita in EU (kilogram/capita) (EC, 2017)

Depending on the method applied to municipal waste, the situation in the EU is presented in Figure 1.95. It can be noticed that the overall rate of recycling (material recycling, composting and digestion) is increasing, in 2012 it was 41.5%, and in 2017 it was 46.9%. This improvement in recycling rate is a combination of a reduction in the amount of municipal waste generated and the increase in the total recycled, composting and digestive amount (Karak et al., 2014). This growth is considered a success for environmental policy in Europe from 1990 to the present.

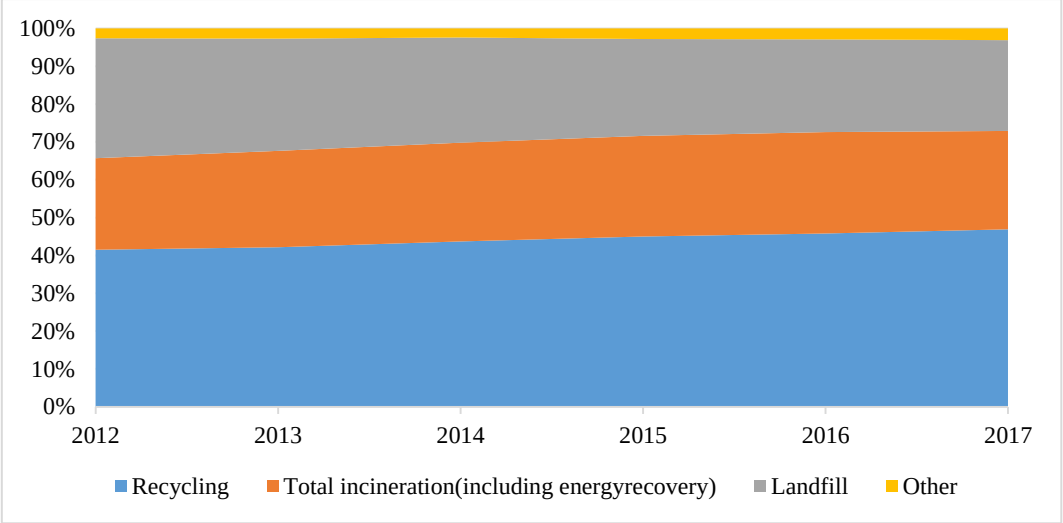


Figure 1.95. Share of treatment methods of municipal waste (EC, 2017)

Municipal waste is covered by EU rules and regulations to be reduced (Pires et. al.., 2011). Recycling rates for 2012-2017 are shown in Table 1.71. It can be seen that the recycling rate has increased annually. This recycling rate is expected to increase annually so that in 2025 it will reach 60%. From the perspective of the municipal waste recycling rate, for EU the situation of the rate increase targets is presented in Table 1.72. It can be seen that the recycling rate is expected to increase by following the objectives of sustainable development (17 Global Goals for Sustainable Development).

Table 1.71. Municipal waste recycling rate in the period 2012-2017 in the EU

Year	2012	2013	2014	2015	2016	2017
Recycling rate (%)	41.5	42.5	43.6	45	45.8	46.9

Table 1.72. Recycling targets for municipal waste

Year	By 2025	By 2030	By 2035
Percentage of recycling (%)	60	65	70

The situation in Romania

In Romania, the competent decision-making and controlling authority in the field of waste management is the Ministry of Environment. Municipal waste includes household waste, industrial and institutional waste, commercial waste, street waste, park and garden waste, waste from urban water purification and construction and demolition waste (Rada et al., 2017). Waste management in Romania includes the following municipal waste management infrastructure (Ministry of Environment, 2017): 51 transfer stations; 101 sorting facilities with a total capacity of approx. 2,431,420 tons / year; 22 composting plants with a total capacity of approx. 180,000 tons / year; 3 mechanical-biological treatment plants with a total capacity of 117,000 tons / year; 35 warehouses with a total built-up capacity of 48.1 million tons and 15 non-compliant

warehouses with assisted activity in 2016 or 2017. Out of the 101 sorting facilities only 93 are sorting facilities, the remaining 8 having authorized sorting waste from the pile. The 93 screening plants have the following sorting capacity, Table 1.73:

Table 1.73. Capacity of sorting facilities in Romania

Capacity of sorting installations	Capacity of installations
93 are sorting equipment installations in Romania	34 plants have a total capacity of about 200,000 tons / year and sort recyclable waste collected separately; 34 plants have a total capacity of about 700,000 tons / year and sort municipal waste collected in the mix; 25 plants have a total capacity of about 1,381,420 tons / year and sort separately collected recyclable waste and municipal waste collected in the mix.

More than 45 sorting stations are currently being implemented and their number will be close to 150 nationally. Most are funded through environmental programs. The composting stations are continually developing. New composting facilities are being built and their number is close to 45. New mechanical-biological treatment plants are being developed including an additional 14 (MM, 2018). The total capacity of mechanical and biological treatment facilities is 1,459,000 tons / year. The amount of waste generated per capita is shown in Figure 1.96. It is noticed that during the period 2012-2015, the amount of waste is decreasing, followed by an increase during the period 2016-2017. This evolution of waste is due to the industrialization and increase of the socio-economic level.

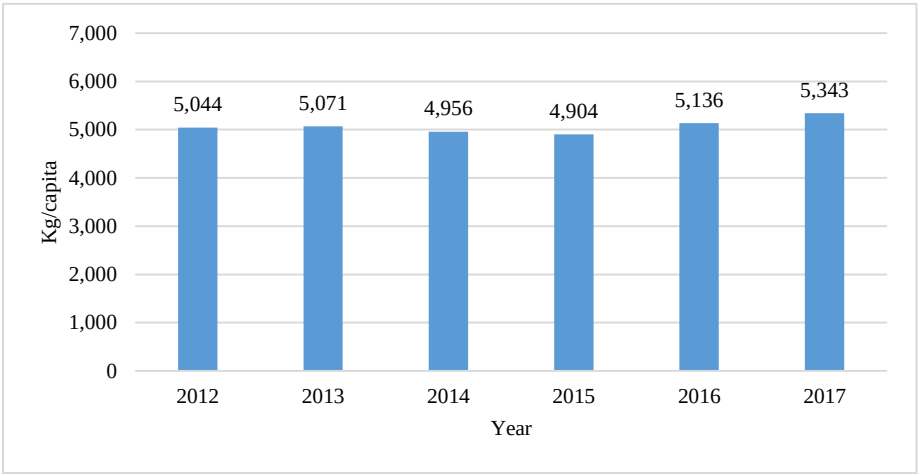


Figure 1.96. The amount of waste generated per capita in Romania (kilogram/capita) (NIS, 2017)

In Romania, the recycling rate of municipal waste is well below the average recorded at the EU level. This rate is shown in

Table 1.74. It is noticed that starting with 2012, the recycling rate is on the rise. This growth is slow, succeeding in 2017 to reach the level of 14.5%.

Table 1.74. Recycling rate of municipal waste in the period 2012-2017 in Romania (NIS, 2017)

Year	2012	2013	2014	2015	2016	2017
Recycling rate (%)	12.8	13.2	13.1	13.2	13.3	14.5

Effective municipal waste management at national level is achieved through collection operators and treatment operators

Strategic framework for municipal waste management in Romania

The situation in Romania needs to be improved to meet the EU's waste management levels. From this perspective, proposing a strategic framework and activities is important. Figure 1.97 shows a strategic framework taking into account the three directions: at sources, as discarded, and at disposal sites.

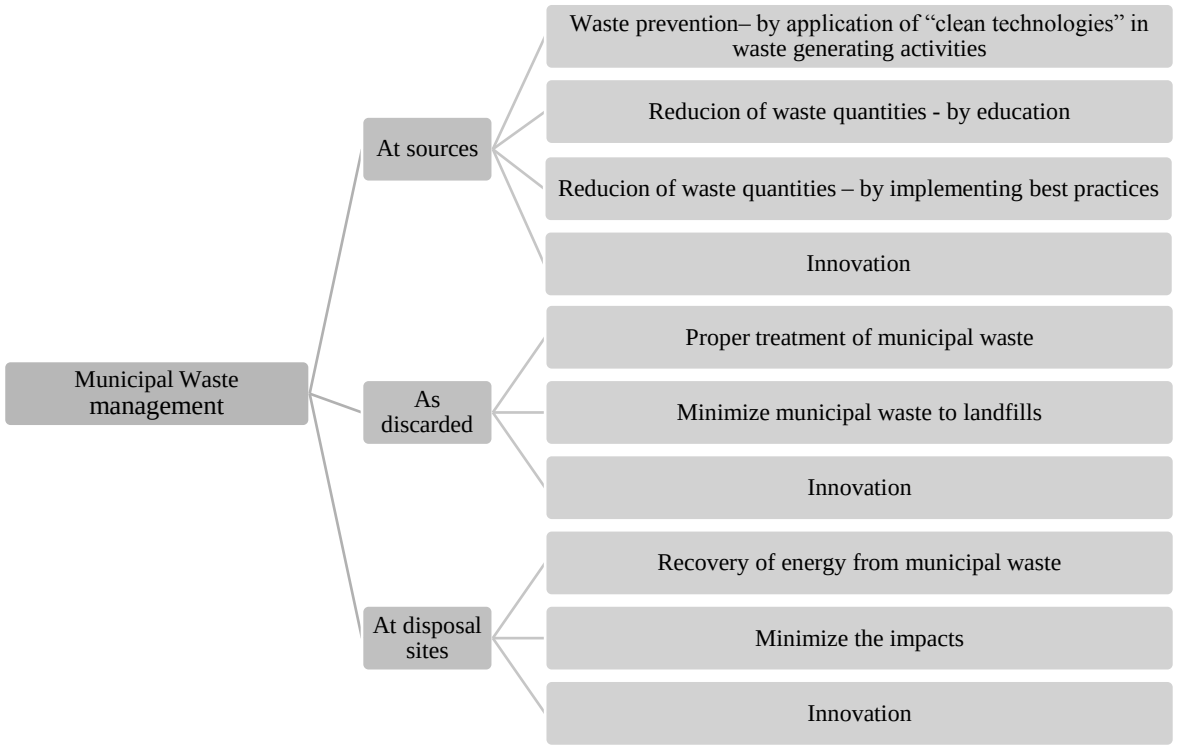


Figure 1.97. Strategic framework proposed to improve the current situation in Romania

The actions to be implemented to increase the quality of the waste management system are related to the existing infrastructure, the human resource involved in waste management activities, and the population. The general strategic objectives for waste management are (Ministry of Environment, 2018):

- Legislative policies and applicable norms - streamlining their application, integrating legislative requirements with economic environmental norms, harmonizing national norms

with European norms. Harmonizing and developing national requirements in harmony with European ones.

- Human Resources - Professional training of human resources in accordance with national and European requirements.
- Enhance financial management - reduce costs and apply the "polluter pays"
- Promoting and informing people and agents about the current state of waste management and EU rules and objectives.
- Integrated system - implementation of integrated IT systems for real-time, complete and relevant situations. These situations can be used in future decisions.
- Preventing waste generation - awareness and training of the population on reducing the amount of waste generated.
- Waste recovery - exploring technological and economic opportunities for waste recovery.
- Efficiency of waste collection and transport - the use of innovative and sustainable systems.
- Waste treatment - using waste treatment to ensure rational environmental management.
- Storage - reducing the amount of waste stored to protect the health of the population and the environment.
- Research and development - encouraging and supporting waste management applications to identify the most innovative techniques and methods that are applicable at national level

Summary of findings

Assessing the research, we can conclude on the following aspects regarding Romania's capacity to comply with EU waste recycling requirements:

- Investing in innovation to increase the technology rate of this sector;
- EU objectives and rules follow the 17 sustainable development objectives and related measures;
- EU objectives and norms are moving towards increasing recycling rates;
- The recycling rate in Romania is 14.5% below the EU level of 46.9%;
- Selective collection infrastructure complies with European provisions, but needs to be improved;
- The selection infrastructure must be expanded so that the recycling rate can increase;
- The amount of waste / capita may grow annually as a result of industrialization and socio-economic stability;
- Efforts to reduce environmental pollution should be sustained and implemented at the level of each EU country.

At national level, waste management activities are carried out on the basis of the following principles: the principle of primary resource protection, the precautionary principle related to the use of ‘best available techniques not entailing excessive costs – BATNEEC”, the prevention of generation, the 'polluter pays' principle correlated with the principle of producer responsibility and user responsibility, the principle of substitution, the principle of proximity correlated with the principle of autonomy and the principle of subsidiarity. Romania's recycling level is well below the EU level, so the current rules and provisions should be revised. The

degree of innovation can be improved, and information and education of the population could be solutions for increasing the recycling rate.

1.5.4. Strategies for developing sustainable products to reduce environmental impact

In the current environment it is increasingly emphasizing the need for involvement in sustainable development. This is a nationally, but also internationally requirement. To succeed in business, the company needs to acquire a commitment to sustainability and to include it in the company's vision. This commitment is an integral part of the company's values and leads to goals attainment. A strong sustainability strategy includes understanding how society, technology and environment influence company processes and conscious modalities to implement sustainable practices throughout every aspect of its business. This section presents the strategies used for four P's of Marketing and presents the sustainability's barriers encountered in the production of sustainable articles / items. The research is based on public information and observation visits conducted in various companies.

At international level there is a significant interest in increasing consumer demand and for the companies to move towards a sustainable direction. Sustainable development, as the action can be defined as … "sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (United Nations Economic and Social Council, 2015). The market covers various products that meet increasingly more the terms of sustainability, i.e. balanced consumption of resources by design. The focus is increasingly on natural products without dyes, protecting the environment and society, so this directive defines consumer behaviour (Munoz, 2008). So can we talk about market sustainability? In some studies it is shown that one cannot speak of sustainable market because the market is based on principles of maximization (production, consumption and prices). This desirable framework is also used to describe the other possible types of traditional markets. In addition to the above, it is shown through a simple model that only the perfect sustainable market is durable because it is driven by optimal forces (production, consumption and market prices) (Mocan et al., 2015; Cioca et al., 2015). Certainly one cannot speak of a sustainable market, but we can talk about the sustainable direction that the consumer market is heading. Companies that adopt the principles of sustainable development due to (Kinoti, 2011; DRaghici et al., 2015; Ivascu et al., 2018):

- Improving the image in rural development;
- Improving the environmental footprint of emissions of pollutants;
- Increased commitment to consumers;
- Loyalty and respect of the consumers that find on the market suitable products for healthy living;
- Durability of the conduct of business and the impact on competition.

Unlike traditional operating companies based on triple fundamental line: Consumer, Profits, Production, and the sustainable companies are operating on the basis of the triple baseline of sustainability: Social, Economic, and Environment.

Triple fundamental line includes:

- Consumer: companies research the needs and wants of customers and develop products in accordance with demand from the market for recording a maximum profit.
- Profits: most managers assume maximizing profits as the direction of development (Katiyar, 2015). Profit maximization is consistent with maximizing the value of the market (i.e. stock price) of the company.
- Production: companies produce what is required in line with the strategy defined. No account is taken of the European global development directions.

Triple sustainability baseline includes the following (Sharma, 2011):

- Environment: the impact of the campaign activities on the environment broadly – natural resources usage, rejecting the entire nature, territory occupation; from the perspective of marketing, from product conception they should be designed in accordance with the imperatives and environmental conditions of the industry.
- Economic: collecting financial performances, their impact on the economic growth in their field of activity and obeying the ethical principles in business; this coordinated marketing activities are conducted in compliance with environmental and social imperatives, but with a balance of economic outlook.
- Social: the social consequences of the company as a whole its representatives: employees, solicitors, clients, local community; the society and its needs must be integrated in product design.

The companies which operate under the fundamental triple line lead to a market based on principles of maximization and companies which are included under the umbrella of triple sustainability baselines lead to sustainable market (Katiyar, 2015). Further there are considered sustainable market strategies related to marketing mix, but also the barriers encountered in this direction. Finally conclusions and future research directions are presented.

Sustainable Strategies Applied in Marketing

Green marketing implies developing and promoting products and services that meet the needs of consumers and business users through the balanced use of natural, cultural / societal resources, and economic resources. This entire endeavor is responsible for ensuring a good quality of life now and in the future (Katiyar, 2015). Sustainable marketing is not only about actions by the company to highlight its care for the environment or consumers, but adds new methods and requirements to traditional marketing:

- Understand fully the values and behaviors of the purchasers directed towards sustainable development,
- Knowledge of market developments from sustainable perspective,
- Organizational commitment to sustainability and positive relationships with their customers, communities and the planet,
- National and international requirements on sustainable development

Sustainable marketing plan focuses on the marketing mix in order to achieve maximum profit potential while respecting the principles of sustainability. For an effective approach to sustainable marketing, i.e. basic four Ps (product, price, placement and promotion) the sustainability principles should be applied and should be aligned with the overall marketing

strategy. Based on these ideas, green marketing plan requires the following (Draghici et al., 2015):

- The four Ps base should integrate sustainability requirements from the design stage,
- Customer segmentation of the target market must be carried out in accordance with the consumers which identify best with potential customers or buyers of the product or service,
- Physical products may be sustainable if we take into account ways of reducing the materials used, minimize the negative impacts of the production process, and maximize the efficiency of distribution,
- Changes implemented in the process of packaging, for example to encourage reusable or biodegradable bags; the existence of an inverse correlation with environmental impact in order to reduce the environmental impact of a product while profitability may increase,
- Sustainable goods that can be more costly from the price perspective than traditional products because production processes have to be optimized by reducing the amount of resources used by implementing new techniques and technologies (renewable sources, energy production on its own, waste reuse and others). This should be taken into consideration in developing branding, marketing mix development, and identifying target segment.
- Using different environments to promote through the integration of IT technologies and online media promotion is adequate support to effectively and efficiently reach the target market with a consistent brand message and call to action.

The directions from above contribute to the development of a sustainable marketing plan designed to achieve the company's objectives. Companies' goals are established in the current economic context in which it emphasizes the need to develop a green marketing mix directed toward the environment, technology and society.

Figure 1.98 presents a conceptual framework of development green strategies applied in marketing based on sustainable development. With the support elements presented and discussed, this model incorporates concepts and important directions. This model is based on the proposals of authors (Kinoti, 2011; Sharma 2011; Katiyar, 2015).

Barriers of Sustainable Product Development

All Even if the direction of the development of green products remains viable and a priority, the question arises *why some consumers do not buy natural / green products?* It discusses the three key barriers facing companies: *price, performance, technology and behavior change.*

When it comes to natural products there is a clear direction to price and performance level. Often customers do not want to pay more for a better product. Buyer behavior changes according to the dynamic o the environment, so using new technologies these desires can be satisfied. Product performance is ultimately proof of higher financial implications (Kinoti, 2011; Sharma 2011). These barriers can be seen as problems to be solved by each company through different strategies of marketing mix.

The New Rules of Green Marketing and Conclusions

Green marketing rules contribute to the goals of the company and generate new opportunities. Benefits (Kinoti, 2011; Sharma 2011) obtained by applying this green marketing are:

- Profitability: "green products" (bio, natural products) have fewer raw materials, less energy and results in fewer waste.
- Competitive advantage: companies that focus on innovation enjoy an increased competitive advantage.
- Increasing market share: the production of beneficial consumer items and protecting the environment, the company attract new buyers. Also the quality offered contributes to increased market share.
- Best products: products are safer, healthier and not least better.

More and more companies are adopting new rules and procedures for the development of competitive products because it "causes" market dynamics.

Developing sustainable products is a challenge for every company. Finally this challenge involves a number of risks. Therefore, sustainable marketing risks can be divided into four categories: market risks, operational risks, the risks of image and communication risk. In future research we will analyze these classes of risks and how they contribute to the development of new opportunities.

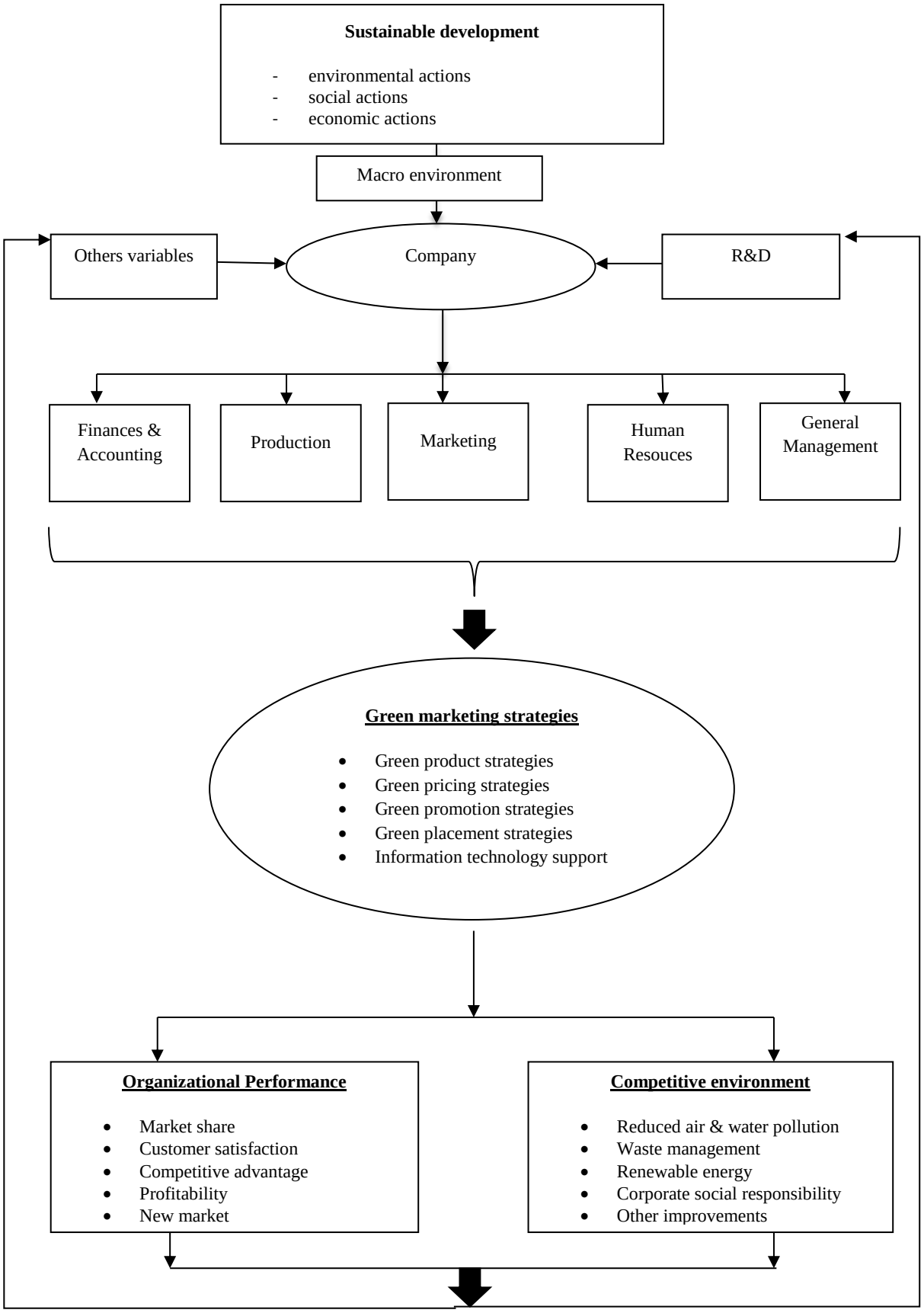


Figure 1.98. Conceptual framework of green marketing strategies and sustainable development

1.5.5. Modelling the green supply chain in the context of sustainable development

This part presents research about green supply chain management and highlight the differences between green supply chain and traditional supply chain management. Sustainable development has gained much attention in recent years as a "challenge" for all businesses. Finally, this section makes a modelling of the green supply chain in the context of SD and presents an interface tool for risk assessment in the green supply chain.

Sustainability refers to the ability of being durable that persists with time. So, in (Shuo, Wei, 2013) "…The essence of sustainable development is creating environmental and social conditions for earth enduring system, so that can benefits mankind. It clearly indicates the absolute dependence of human on earth enduring system". The sustainability development can be seen as an additional requirement in the development of organization processes and achieving the objectives of the enterprise (Ivascu et al., 2014; Moraru et al., 2010).

The concept of sustainable development leads to the analysis of the factors which contributed to the changes in the environment and in the health of the population due to polluting of the water, air, ground and others. These decisive factors are especially the greenhouse gases which release carbon dioxide and methane into the atmosphere. Greenhouse gases (GHG) are developed in the environment following natural processes and human activities. Water steam is the most frequent in the atmosphere. Due to human activities considerable other quantities of other GHG are released into the atmosphere, thereby increasing their atmospheric concentration – and thus intensifying the greenhouse gases and warming up the climate.

These greenhouse gases are released especially by:

- burning of fossil fuels (coal, rock oil, natural gases) to produce energy for transportation, industry and households (CO_2);
- agriculture and deforestation;
- storage of household waste and the lack of local and national waste management;
- the use of fluorinated industrial gases.

The main sources of carbon dioxide emissions are the combustion of the energetic sector, the emissions from road transport, non-industrial combustion plants and combustion in the manufacturing industry. Within literature studies (Srivastava, 2007; Bajdore et al., 2011; Hugos, 2011; Sarkis, 2011) one can observe that transportation is a polluting element for which actions to reduce the impact on the atmosphere have to be imposed. By analyzing the implications of sustainability one can observe that the development possibility on the sustainability axis does not exist without the actual support of technology. Technology is present in every activity, being an element which sustains and contributes to the optimum development of a company's processes. This tool can be used to optimize the activities and also for the supply chain. The recent technological advancement allows a series of actions to optimize transportation and to develop an optimal architecture. The sustainable balance of the system is heavily influenced by risk appearance. Evaluating risk in the context of sustainable development leads to an optimal handling of these risks, to the stability of the system, without compromising the needs of future generations. Developing the balance at company level

implies evaluating associated risks and hazards so that the company contributes to the welfare of the society and the planet.

Green supply chain and traditional supply chain

Supply chain is defined and interpreted within the literature by several authors. Ganesh and Harrison (1995), define the supply chain as"a Network of facilities and distribution options that performs the functions of procurement of materials, transformation of these materials into intermediate and finished products, and the distribution of these finished products to customers". Chopra and Meindl (2003) highlight that"a supply chain consists of all stages involved, directly or indirectly, in fulfilling a customer request. The supply chain not only includes the manufacturer and suppliers, but also transporters, warehouses, retailers, and customer themselves".

In 2011, based on Hugos, five major factors within the supply chain which interact amongst them are presented (Figure 1.99).

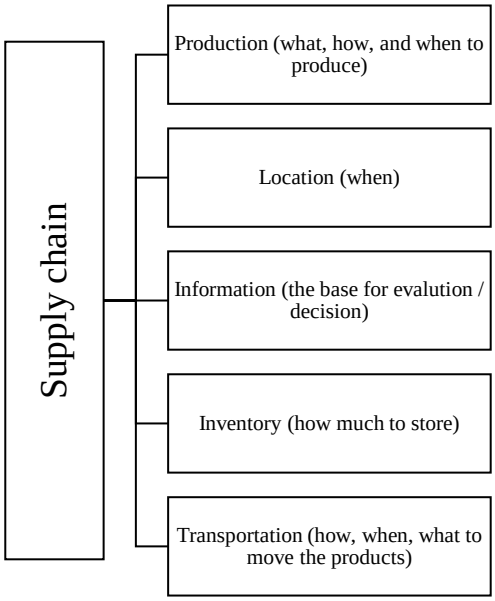


Figure 1.99. Five major factors in the supply chain (after Hugos, 2011)

Compared to the supply chain, the green supply chain (GSC) implies approaching factors according to the imperatives of the environment and adopting strategies in the sense of sustainable development. Hence, Bajdor and Grabara (2011) systematize the concept in the following manner (Figure 1.100).

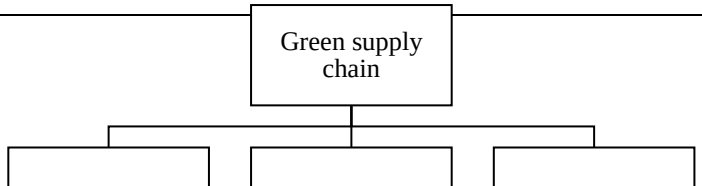


Figure 1.100. Green supply chain (after Bajdor and Grabara, 2011)

Green supply chain management (GSCM) has already won an increased interest within researchers and companies (Ojo, 2013; Darnall, 2008; Sheu, 2005). The growing importance of this concept is due primarily to the deterioration of the environment, inefficient waste management and diminishing raw material resources. Adding the term "green" to supply chain implies approaching the supply chain from the traditional perspective by corroboration/combination with the natural environment. Zhu et al. claims that GSCM can be considered as an environment innovation. Zhu and Sarkis highlight that GSCM has ranged from green purchasing to integrated supply chains starting from supplier, to manufacturer, to customer and reverse logistics, which is "closing the loop". Srivastava (2007) said that GSCM can be defined as "integrating environmental thinking into supply chain management, including product design, material sourcing and selection, manufacturing process, delivery of the final product to the consumers as well as end-of-life management of the product after its useful life".

Transportation's role in reducing greenhouse gas emissions

Greenhouse Gas Emissions and Global Climate Change

Transportation, as a component of supply chain has a significant impact on the environment (Coyle et. al., 2010; Cioca et al., 2015). Transportation is a complex contributor to national greenhouse gas emissions, and can be part of the Nation's solution to the climate change challenge.

The Intergovernmental Panel and Climate Change (IPCC) estimates that in the absence of adopting some policies and solutions to reduce GHG, emissions will increase to 110% between the years 2000 and 2030. The IPCC projects that global temperatures will rise between 2°F to 11.5°F by 2100, and global sea level will rise between 7 to 23 inches. More recent estimates that include the effects of polar ice sheet melting suggest a possible 3 to 4 foot sea level rise. IPCC said that, global GHG emissions must be reduced to 50 to 85 percent below year 2000 levels by 2050 to limit warming to 2.0°C to 2.4°C (3.6°F to 4.3°F). To reach this target, GHG emissions from all sectors must be reduced through a multi-generational effort (Report US, 2010). By analysing the quantity of carbon dioxide emissions at European Union level, it was found that the largest quantity has resulted from producing electric and thermic energy within each individual country. For example, producing energy based on coal within EU states has

generated around 950 million tonnes of CO2 emissions in the year 2005, which represents 24% of the total CO_2 emissions in the EU, Table 1.75.

Table 1.75. Share of CO_2 emission by activity sectors in the UE states (data source: International Energy Agency – IEA), and Share of CO2 emission by activity sectors in Romania (data source: International Energy Agency – IEA)

Domain	Share of CO2 emission by activity sectors in the UE states	Share of CO2 emission by activity sectors in Romania
Electricity and heat production	40.2 %	48 %
Other industries	4.2 %	8.1 %
Construction and manufacturing Industry	16.9 %	16.7 %
Transport	19.2 %	18.2 %
Rezidential sector	12.1 %	6 %
Other commercial sectors, public and agriculture	6.1 %	3 %

After the electric and thermal energy sector, the transportation sector is the next big polluting element given all companies divided based on activity sectors. The transport system is the most important economic activity among the components of business logistics systems. It is fast becoming a complex factor in determining the difference between profit and loss. This concept is the essential link between the extraction of natural resources; the fabrication of industrial, commercial, and consumer products; and the final distribution of goods to wholesalers, retailers, and end users.

Bringing the GSC concept into discussion, transportation needs to be adopted according to the environment and by implementing strategies in this sense. Speaking about GSC, certainly all key factors must be re-evaluated so that the impact of GSC on society and environment is minimised. According to location, the type of transportation can be different, whilst the impact on the environment is also different. Within the supply chain transportation is used in the following situations (Figure 1.101).

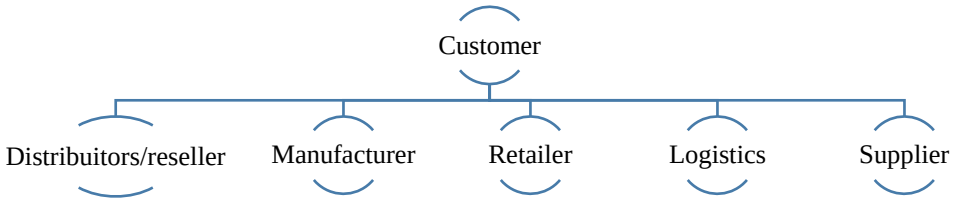


Figure 1.101. Typologies of transportation

As for transport, the fast emissions growth was driven by emissions from the road sector, which increased by 52% since 1990 and accounted for about three quarters of transport emissions in 2011 (IEA, 2013).

Using bio or electric fuels is outlined. Moreover reusing is emphasized, being a condition for sustainable development. In order to reduce the air pollution several strategies can be adopted: introduce low-carbon fuels, introduce electrical transport, increase vehicle fuel economy,

improve transportation system efficiency, reduce carbon-intensive travel activity, and price carbon.

Proposed Green Supply Chain Architecture

Based on the implications of sustainability and the traditional supply chain, the GSC architecture in presented in the following figure (Figure 1.102). The fact that at the base of adopting this new concept the dimensions of sustainability have to be adopted is highlighted, while transportation emissions must be reduced by rendering them more efficient.

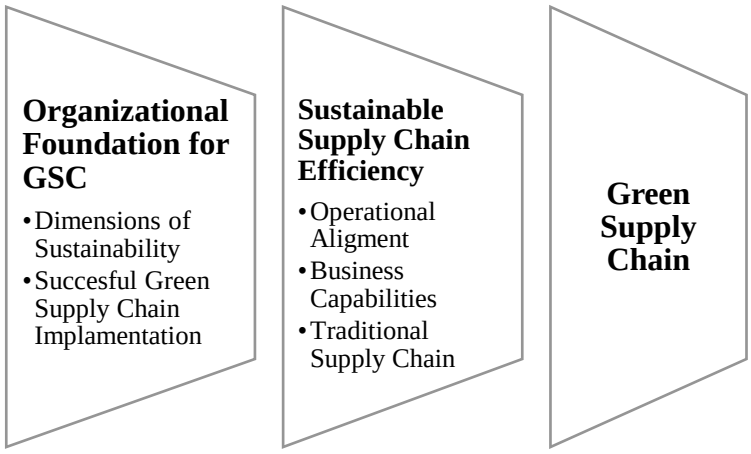


Figure 1.102. Deployment Diagram for GSC

The GSC concept imposes companies to adapt to present requirements of the economy, being a step in their development. Approaching the supply chain by a green perspective first of all implies an increased attention given towards society and the environment. Thinking green, probably, has become a normal activity because all the activities are headed towards sustainability and hence towards the environment and society. The transportation activity represents a pillar of support in the economic environment, but it contributes to polluting the environment in the same time. In spite of the reduction of emissions within the last decades, traditional supply chain still remains a major source of pollution.

In order to reduce and control CO_2 emissions resulted from transportation activities there is a proposition for a directive of the European Parliament and the Council (the prevention and the integrated control of pollution). In order to prevent, reduce and control CO_2 emissions resulted from transportation, a series of measures and actions are necessary, as are the following:

- the increased use of new technologies,
- introducing dispositions regarding inspections and improving environment protection,
- stimulating innovation and the development and use of new techniques.

This part systematizes data relating to supply chain in Romania and the EU. By modeling the supply chain process is presented its architecture. The GSC concept imposes companies to

adapt to present requirements of the economy, being a step in their development. Approaching the supply chain by a green perspective first of all implies an increased attention given towards society and the environment. Thinking green, probably, has become a normal activity because all the activities are headed towards sustainability and hence towards the environment and society.

1.5.6. Assessment of climate change and its impact on Romania – ICSS2015

Climate change is a complex process that affects society and the environment. They are a threat to renewable energy from the perspective of sustainable development. The observations and measurements indicate certain signals produced in Romania, which support this hypothesis of climate change. This requires a range of strategies for building a sustainable energy model for reducing carbon dioxide emissions. In this way the climate change is mitigated and the nuclear energy option is completely removed. In Romania there are considerable steps in this direction. This national direction is correlated with international standards. This section presents the situation in Romania in terms of climate change and its impact on renewable energy sources. Finally, the conclusions of this study are presented and Romania's strategic directions for this.

Climate change is a global process with direct impact on resources. With priority, these climate changes have a direct effect on society and the environment. According to the International Agency for the Environment (International Energy Agency, 2014), the damage will increase significantly and each component of the economy must adapt to this approach and reduce emissions. There are a number of actions at the international level, but also nationally. Climate change is a double challenge for every state in part: (1) the serious effects of climate change can be avoided only by reducing greenhouse gas (the core of EU policy is associated with keeping global average temperature increase to 2° C compared with the pre-industrial period); (2) The whole society faces in parallel, the challenge of adapting to the conditions created by these changes. Climate change is inevitable even if the international actions in this field prove to be effective and properly implemented. Therefore, the first challenge is the partially controllable direction that can be improved in each country. Carbon dioxide is the most polluting gas (of the greenhouse gases that affect climate change).

The Context of Climate Change

International initiatives for environmental protection

At international level there have been issued a series of actions to protect the environment (Ministry of Environment of Romania, 2013). The first action to reduce this phenomenon occurred in 1992, in Rio de Janeiro by signing the United Nations Framework Convention on Climate Change (UNFCCC), adopted in Romania by Law no.24 / 1994, whereby the 194 signatory countries agreed to work long-term for reducing the intensity of greenhouse gas emissions (GHG) in the atmosphere. These GHG lead to negative effects on society. In 1997, 5 years after the Rio de Janeiro Convention in Kyoto, Japan, a number of developed countries systemized the action to combat climate change by taking some steps to limit and reduce emissions of greenhouse gases in the period 2008-2012 and they identified means of international cooperation in obtaining the benefits and achieve the proposed objectives.

Currently, there are 192 Parties (191 States and one regional economic integration organization) to the Kyoto Protocol to the UNFCCC. Romania signed this protocol on January 5, 1999. Among the important actions of this protocol there are included (Zia, 2013; Seo, and Kim, 2013):

- Reduction of greenhouse gas emissions for the signatory countries in accordance with the future requirements;
- A greenhouse gas emission-trading program;
- Organizing future actions for monitoring and sanctioning the member states that do not respect their obligations under the signature of this protocol.

Among the problems expressed above, two of the most difficult problems unresolved in 1997 in Kyoto are still in discussion at international level:

- Emissions Trading - is one of three "flexibility" mechanisms contained in the Kyoto Protocol (article 17);
- Reducing carbon emissions through forests, soils and agricultural practices.

The Kyoto protocol addresses the emissions issue of six greenhouse gases: carbon dioxide (CO_2); methane (CH_4); nitrous oxide (N_2O); hydrofluorocarbons (HFC); perfluorocarbons (PFCs), sulfur hexafluoride (SF_6). This is an important step in the fight against global warming, containing clearly defined and quantified objectives for limiting and reducing greenhouse gas emissions at national and international level (Zia, 2013).

The scientific reports show that to achieve the goal of UNFCCC there should be developed intense action from all countries so globally to register a decrease in GHG by at least 50% in 2050 compared with emissions in 1990. This level can be achieved only if the developed countries will reduce GHG together with the percentage values contained between 60-80% in 2050 compared to 1990 emission levels (Seo, and Kim, 2013).

Wanting to maintain the leadership role, the EU unilaterally adopted in 2007 a series of actions and proposals to reduce the factors that lead to global climate change. According to the European Commission, for 2020, the EU has committed to cutting its emissions to 20% below 1990 levels. Besides this objective, in fighting climate change, there are established and accepted by all EU countries and the following objectives:

- 20% reduction by 2020, of greenhouse gases emissions compared to 1990 levels - it is shown that EU makes considerable steps for emissions reduction for as much as 30%, provided that other developed countries take similar commitments and the developing countries join this initiative in accordance with nationally available possibilities;
- increasing the share of renewable energy up to 20%;
- increasing by up to 20% of the energy efficiency.

In this context, for 2030, the European Commission proposes that the EU set itself a target of reducing emissions to 40% below 1990 levels by 2030. Going further evolutionary, for 2050, representatives of EU approved GHG reduction target of 80% -95% compared with 1990. The

European Commission presented a series of cautions and proposals which can be implemented in supporting and developing this approach. These actions are:

- The EU Emissions Trading System - has become a key instrument in the EU approach to reducing GHG emissions at the international level;
- Adopting legislation for the use of renewable energy used in the production of the consumed energy; Granting subsidies for the use of optimal systems to capture resources needed to produce energy;
- Setting a target to increase Europe's energy efficiency by 20% by 2020 by improving the energy efficiency of buildings and the quality of household appliances;
- Reducing carbon dioxide emissions for transportation;
- The European Climate Change Program (ECCP), which has led to the implementation of dozens of new policies and strategies.

In a press release from the European Commission it is stated that "CO_2 is the greenhouse gas most commonly produced by human activities and it is responsible for 64% of man-made global warming. Other greenhouse gases are emitted in smaller quantities, but they trap heat far more effectively than CO_2, and in some cases are thousands of times stronger. Methane is responsible for 17% of man-made global warming, nitrous oxide for 6%" (European Commission, 2015). For the above mentioned period, 2008-2012, EU-28 Member States overachieved their targets by a total of 4.2 Gt CO2-eq. For the next period, 2013-2020, 2013-2020, total emissions (excluding LULUCF – Land use, land-use change and forestry, and international aviation) are expected to be 23 % lower than base year, 1990, levels according to Member States' projections. In the next period, it is aimed a potential overachievement of 1.4 Gt CO_2-eq.

Each member state is in line with the objectives proposed at European level and manages, within available resources, to control climate change through the use of renewable sources in daily activities. These renewable sources help reduce GHG emissions and maintain an acceptable level of climate change.

Climate change in Romania

Climate change in Romania fits into the overall context, having regional conditions: in summer temperature rise is recorded, while in the north-west Europe the highest rise is expected in the cold season. According to estimates presented in the IPCC AR4 (Intergovernmental Panel on Climate Change - "Climate Change 2007: Synthesis Report"), Romania will register higher temperature compared to 1980 to 1990, similar to the whole of Europe, existing little difference according to the period:

- from 0.5 ° C to 1.5 ° C for the period 2020 to 2029;
- between 2.0 ° C and 5.0 ° C from 2090 to 2099.

From the pluviometric perspective, most climate models forecast for the period 2090-2099 serious drought in the summer for Romania, especially in the south and south-east (with negative deviations from the period 1980-1990 more than 20%). Rainfall and cold seasons are reduced and uncertainty is higher (Ministry of Environment of Romania, 2013). Romania's

National Strategy on Climate Change 2013 - 2020 was adopted in Romania and provides two main directions:

- to reduce emissions of greenhouse gases and
- the use of natural tanks for carbon dioxide sequestration. This direction is supported by the United Nations Development Programme (UNDP) in Romania.

As presented in the literature (Duflou et al., 2013), the average air temperature increase, mainly in recent decades is clear confirmation of climate change taking place in Romania, but also globally. This increase in temperature leads to imbalances in economic sectors (eg: forestry, agriculture, tourism, beekeeping, insurance industry, et.al.). For some sectors, such as tourism, these climate changes are positive leading to improved financial situation, according to various indicators. In contrast, for other fields (for example: winter sports), these changes are perceived negatively. Surely for the human body, climate change leads to imbalance (Cioca et al., 2015). Climate change leads to strong reactions chain triggered which may endanger the equilibrium of fragile systems. Natural disasters are significant threats in socio-economic terms of the country.

Assessment of the national situation

Climate changes are felt in Romania, because these climate changes have as the main factor greenhouse gases emissions. The energy sector is thus developing the largest quantity of GHG per year, with a slight decrease since 2006. In Romania, the data related to the years 2000–2011 are presented by the National Institute of Statistics (NIS). For the years 2012–2014, NIS does not present the data on GHG emissions.

Carbon dioxide is the gas with the largest share of GHG (Duflou et al., 2012). For Romania, the share of carbon dioxide emissions is presented in Table 1.76. Thus, the energy sector should be improved to reduce emissions. This sector can be improved through the use of renewable energy. Analysis of renewable energy sources in Romania is shown in Table 1.76. It is observed that carbon dioxide emissions are produced mainly by: electricity and heat production, transportation, and industrial sector. The "Total" line of Table 1.76 comprises the net quantity of CO_2 (sequestrations and emissions) and quantities of CO_2, CH_4 and N_2O (emissions) for the LULUCF sector.

Table 1.76. Total GHG emission (thousand tons)

Type/Year	2000	2005	2006	2007	2008	2009	2010	2011
Energy	104.338,29	113.521,44	118.038,25	117.506,44	116.165,41	92.055,61	90.808,74	98.054,21
Energy	92.894,36	96.602,11	99.709,24	96.123,48	95.965,23	82.877,82	79.624,01	86.320,46
Industry sector	16.826,43	18.223,69	19.355,61	20.624,73	17.945,58	11.253,06	12.414,25	12.605,14
Waste	5.157,70	5.539,28	5.765,54	5.602,38	5.677,92	5.703,17	5.715,62	5.366,48

Total LULUCF	*-29.219,59*	-28.062,87	-27.862,84	-25.218,88	-24.312,00	- 28.254,61	- 25.830,81	- 25.304,94

Renewable energy sources contribute to the diversification of energy sources available and most likely will gradually replace fossil fuel sources of energy which is continuously decreasing according to existing national data. Using these sources instead of fossil fuels can considerably reduce greenhouse gases and especially carbon dioxide emissions. The situation of solar energy, wind energy, municipal waste, biomass and geothermal sources is listed below (International Energy Agency. IEA Statistics. $C0_2$ Emissions from Fuel Combustion, 2013 Edition).

Solar energy used in the production of energy comes from the sun in the form of solar radiation. Romania is located in the European B area in terms of sunshine (1200-1600 kWh / m² per year). The highest point registers a value of 1350 kWh / m² per year (Romanian Plain). The total capacity installed in Romania at the end of 2012 is 41 MW (Duflou et al., 2012).

In terms of wind energy, the share is below the European average, and in Romania is covering 5% of the total energy. Mountain winds are a main direction in this regard, which can exceed 8m / s. This source is also supported by the Romanian seaside, with a wind speed of about 6 m / s (Ministry of Environment of Romania, 2013).

Biomass is renewable energy source that is obtained from urban waste, plants, animal waste and sun. Romania has a potential biomass of 7.6 million tones ((Ministry of Environment of Romania, 2013). Geothermal energy is represented in Romania by 66 geothermal water sources. Geothermal energy sources have an annual potential of approximately 10 * 106GJ equivalent of 240,000 tep (Ministry of Environment of Romania, 2013).

In Romania municipal waste recycling rate reaches the maximum value in 2011, representing 7% of the total waste collected. Municipal landfills contain high levels of organic and inorganic pollutants arising from chemical biological and physical processes taking place. The amount of municipal waste collected per capita, in 2011, in Romania is 239 kg, down 22% compared to 2008. In the EU-28, the amount of waste for 2012 is 488 / kg / per capita, down 5% compared to 2008 (International Energy Agency, 2014)

Analyzed data on GHG emissions in Romania demonstrates that it remains a gap of at least 50 million tons of carbon dioxide equivalent annually, as the difference between the target value set by the Kyoto Protocol and total emissions in the commitment period of the 2020 convention, even considering the possible uncertainties associated to inventories and projections of GHG emissions.

Renewable energy in Romania - summary, directions and perspectives

Climate change will further affect Romania, creating also opportunities such as using renewable sources. These opportunities also contribute to the development of organizations

that genuinely generate excessive pollution (International Energy Agency, 2014). Data presented in the second section highlights a number of directions and perspectives:

- The need for diversity of energy sources, renewable energy development;
- Adapting the infrastructure to climate change;
- Compliance with public health, including animal health;
- Use incentives to reduce water consumption in human and industrial activities;
- Improvement of ecosystems (conservation and restoration of diversity, reduce negative effects on existing species);
- Adaptation could lead to a complex restructuring of economic sectors that are exposed directly to weather conditions (e.g. agriculture, forestry, fisheries, and tourism).

Climatic conditions can be sustained by developing systemic outlined directions that are aligned to international strategies.

1.5.7. Principles of Circular Economy in Romania, Europe and China

Sustainable development is an approach taken in many companies globally. In this sense, the circular economy is being implemented in many countries. In Romania, a number of companies apply the principles of circular economy in their activities. At European level, there are a number of practices that contribute to the region's competitiveness. China, one of the largest developing countries, is experiencing rapid economic growth associated with high consumption of natural resources. In this context, this part presents the principles and implications of the circular economy and the way in which Romania, Europe and China respond to these practices. This section is based on a qualitative research based on the literature review and a semi-quantitative research by applying a questionnaire to Romanian participants. Finally, a framework for implementing the principles of circular economy within companies is presented.

Sustainable development and circular economy (CE) are concepts intensely addressed in the academic environment, while the defining factors of these concepts and the differences between the two remain ambiguous. Some research show a close link between them, being concepts that contribute to the implementation of sustainable and fair practices at the levels of company, cluster, national, international and global. The implementation of the circular economy began as early as the end of the last century. The basic idea of the CE is to intelligently manage all resources and to provide welfare to more people. It is emphasized that CE is a complete transformation process and not a package of information and data that can be implemented overnight. This process involves new business models, the creation of renewable economies, cyclical supply and use in closed loop. Such an economic and sustainable system involves an agenda for the environment, technology and economy.

Circular economy wants to replace the linear economy. In 1966, Kenneth E. Boulding presents his research of the idea of a flow of circular materials (Kenneth, 1996). In the 1970s, the CE began to develop as an alternative economic model, being a challenge for the traditional linear industrial economy. Assessing the implications of the traditional economy, it is noted that it is based on a linear process, developed for high production and low costs, on the abundant

availability of raw materials at a relatively low cost. The whole process is a common one that consists of a series of successive stages starting from resource extraction, manufacturing, consuming and eliminating products at the end of their life cycle. On the other hand, the CE relies on protecting the environment by minimizing waste and overuse of resources, transforming end-of-life goods into resources for other processes by reusing, re-designing, recycling, reducing waste and other practices (Frodeman Robert, 2011; Stahel, 2011; Lehmann, et al., 2014). Within the CE, the value of products, materials and resources is maintained in the economy for a longer period of time, and waste is minimized to reduce pollution and greenhouse gas emissions.

In June 2012, the United Nations Conference on Sustainable Development (Rio + 20) focuses on reducing the impact on the environment. In fact, CE is a loop-locked system for materials and energy (Lehmann, et al., 2014). This concept contributes to the sustainable development of companies and nations. At the level of Romania, there are a number of business models and practices in the direction of the CE. China, being one of the drivers of the concepts, adopts and implements CE principles in most areas of activity. At European level, there are guidelines and principles defined for the development of a business model based on the CE. The concept is not a new one, it has been used in the subsidiary for centuries. The novelty consists in managing the closed loop so that the financial results are favourable to the organization.

CE is a concept adopted in many of the existing global companies. The development of the CE concept and practice are closely linked to the dynamics of the current business environment.

So, two questions can be addressed: *Are the advantages and benefits of this concept covering the disadvantages of implementation? Is this concept of the CE a necessity or a practice associated with corporate social responsibility?*

The answer to these questions will be presented in the following sections. Thus, the CE principles associated with Romania, Europe and China will be presented.

The Development of Circular Economy

Assessing the year 2015, it can be seen that the five largest emitting countries and the European Union, which together account for two thirds of total global emissions, were: China (with a 29% share in the global total), the United States (14%), the European Union (EU-28) (10%), India (7%), the Russian Federation (5%) and Japan (3.5%) (European Commission, 2017). In this respect, various principles of circular economy and sustainability to reduce global emissions must be addressed and applied.

Lately, the CE has been extensively debated in the literature (Taranic, et al., 2016), governments and companies (Draghici et al., 2015) as an alternative to the traditional model.

CE often refers to the following six principles (Knight, and Jenkins, 2009; Guo et al., 2017):

- Reduction - use of a minimum level for inputs into production;
- Re-use - use for the same purpose or for different purposes of certain products out of use;
- Recycling - the product no longer conforms to the original use, but some components may be reused or resold;

- Reconditioning - cleansing the base items helps reuse the product;
- Renovation - similar to refurbishment, with the difference that this process involves more resources;
- Remanufacturing - similar to refurbishment, but the process involves more extensive work, even complete dismantling of the product.

The principle of reduction involves the use of minimum inputs of energy, raw materials and waste, for example the implementation of innovative technologies, non-polluting raw materials, simplification of packaging, use of renewable energy sources and optimization of working time. The principle of reuse stipulates that certain non-waste products are to be reused in the production process (e.g. paint dyes remaining after the dyeing process to be mixed and used to colour a fabric that will associate a lower price). The recycling principle refers to the operation by which the waste is reprocessed in products, materials or substances, both for original purposes and for other purposes. The reconditioning principle involves cleaning some items to bring the product to its original state. Renovation involves additional reconditioning activities involving multiple resources. Rebuilding sometimes leads to dismantling a product and bringing resources to the input state of the manufacturing process.

Industries have different positions in front of these CE principles because some principles involve additional resources. Producers who implement CE initiatives seek benefits in terms of competitive advantage, although indirectly, they can increase efficiency (Knight, and Jenkins, 2009). For some manufacturers, some of these CE principles can bring additional costs, while for waste companies, the recycling process is central. That's why each company has to evaluate its processes and the possibility of integrating CE principles into business.

Based on this research of the literature, can be defined the circular economy as a regenerative system in which the amount of input resources in the process, the amount of waste, the energy and the emissions generated are minimized by the closed loop optimization. This is possible through design, reduction, reuse, recycling, reconditioning, renovation, and remanufacturing.

CE in Romania

The main problem in Romania, from the CE perspective, is the high level of pollution. The 2014 Report on the State of the Environment in Romania presents the higher greenhouse gas emissions per unit Gross domestic product than EU average (European Commission, 2017). The practices in Romania related to the CE are concretized by:

- 467 companies per million inhabitants have implemented an ISO 14001 certification in 2015. At EU level, there are 208 companies per million inhabitants. There is an intense concern for environmental protection.
- Concern for companies to reduce the amount of material at the entrance to the process.
- Recycled resources are partly used as production materials, for this there is a certain reluctance.
- Most companies selectively collect waste by implementing waste management policies.
- At the level of Romania, steps are taken to reduce gas emissions. Among the barriers to the adoption of CE practices are listed: low level of collaboration, lack of public sector specialists, funds allocated for green businesses and others.

CE in Europe

European Union (EU) Directives support economic players to have an important role in driving this process. Local, regional and national authorities facilitate the transition from a linear economy to a circular economy, and the EU has the role of supporting these activities. Existing EU regulations support the CE from production, which is the beginning of a product's life, to consumption and waste management. The European Commission adopted a Circular Economy Package, which includes revised legislative proposals on waste for the purpose of transition to the CE and the development of competitive companies. This package includes the proposals:

a. recycling 65% of municipal waste by 2030;
b. recycling 75% of packaging waste by 2030;
c. reducing 10% of municipal waste by 2030;
d. implementing the concept of selective collection in all entities;
e. reducing stocks of materials and products;
f. promotion of economic instruments to discourage landfilling;
g. reduction of gas emissions;
h. reuse of products that have not reached the end of the life cycle;
i. economic support for product recycling (e.g. for packaging, batteries, electrical and electronic equipment, vehicles).

At European level, CE practices follow the principles of design, reduction, reuse, recycling, reconditioning, renovation and remanufacturing. Investments focus on the technologies used in production processes for the sustainable development of companies.

CE in China

Since the 1980s, China has successively issued a number of circular economy policies. These legal fundaments include Cleaner Production Promotion Law, the Energy Conservation Law, the Circular Economy Promotion Law, etc. The law on the promotion of the circular economy focuses on the development plans and the existing management policies at the companies' level. The law on the promotion of the circular economy proposes the requirements for the use of innovative infrastructures. Chinese local authorities encourage the circular economy through special funds, technical support, tax incentives, investment, finance, prices, public procurement and other issues.

In a study that includes four megacities including Beijing, Chongqing, Shanghai and Urumqi, the increased interest of local authorities and companies in reducing CO_2 emissions (Guo et al., 2017) by reducing waste is presented.

This concept of circular economy has been developed in China on four stages

a. before 1992: proper use of materials and products
b. 1991 - 2002: it is characterized by cleaner production and the Chinese State Council has formulated the Top 10 Strategies for Environment and Development
c. 2002-2008: the pilot period for the implementation of the CE and the Chinese State Council formulated a series of practices to reduce gas emissions

d. 2009 - Present: the continuous development period of the CE. Local authorities are directly concerned with lowering the level of gas emissions.

Assessing case studies conducted in Huawei and Suzhou (Lehmann, et al., 2014; Guo et al., 2017), it can be argued that the main actions implemented in the CE direction are:

- Reuse of materials in the production cycle;
- Reduction of inputs in manufacturing processes and use of production equipment up to their failure;
- Implementing the concept of "Cleaner Production";
- Reducing CO_2 emissions by using less polluting materials.

Result and Discussion

As a result of the research, we identified that the main CE actions in each analysed region support recycling as primary action, while support for other types of CE seems to not be of the same magnitude. Regulatory measures have primarily taken into account increased efforts recycling both on the consumer side and on the manufacturer's side.

From the research of the specialized literature it can be noticed that:

- At Romania's level there are opportunities for the development of the circular economy.
- The EU supports sustainability and CE development through the annual update of the information package.
- China is one of the largest developed countries that aligns easily with business trends.
- The CE presents a number of opportunities for companies. Each company can access these opportunities according to their benefits.

The concept of circular economy can be systematized as in Figure 1.103. The seven principles are based on the design phase. In the end, the consumer is influenced and is influencing by his behaviour the production process.

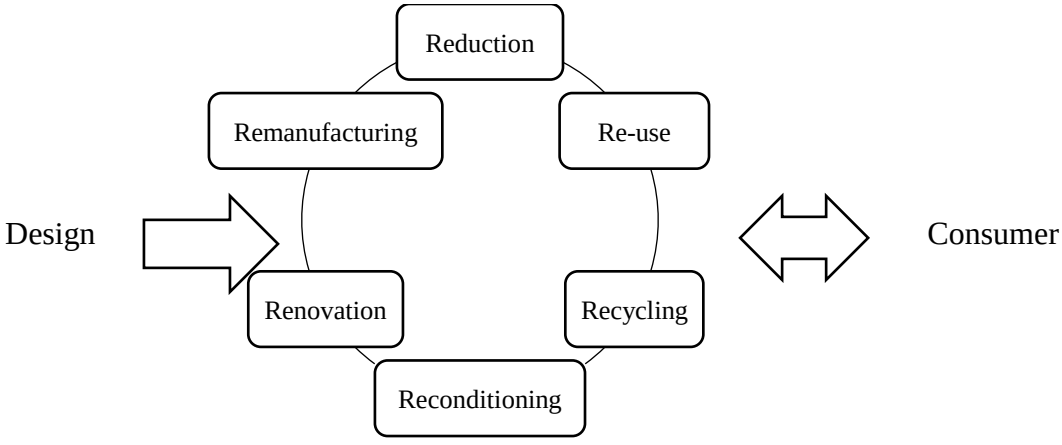


Figure 1.103. The circular economy framework

The CE concept is implemented in the public and private sector at the level of Romania, the EU and China. The degree of involvement in adopting this concept differs for the three rated entities. It is noticed that China has started this implementation of cleaner production since the 1990s. In Romania, this process has experienced an avant-garde since the 2000s. At EU level,

practices and regulations exist and are implemented in many countries such as Germany, Austria, Denmark and others.

2. Achievements. Development perspectives

Achievements and Proposal to develop the academic career addresses two basic issues: **teaching and professional activity** and **research activity**. Career development proposal is based on the candidate's achievements materialized until now and continue with the description of which will focus its future work.

2.1 TEACHING AND PROFESSIONAL ACTIVITY

A1. Achievements so far:

The teaching profession implies responsibility and respect integrated with intense research. This profession, through excellence and content, requires its owner competence, professionalism, dedication and humanism, a permanent training, development and dedication in order to offer the person who learns a comprehensive perspective on the field he teaches and a systemic vision adapted to the demands of the external environment. The feeling of responsibility attached to this profession is based on professional knowledge and skills on the one hand, and on values and norms on the other. Both are essential and complement each other.

I was born on October 17, 1983 in the town of Reșița, Caraș-Severin County.

I attended the courses of **Theoretical High School No. 2** from Reșița, the **Computer Science Intensive** section during 1998-2002. After graduating from high school I attended the courses of the **Faculty of Automation and Computers** at the "Politehnica" University of Timisoara, in the period 2002-2007, the **Computer section**. I took the license exam in June 2007, obtaining the mark 9.76.

I continued my studies with a **Master in Business Administration - Executive (MBA)** at the Faculty of Management in Production and Transport of the "Politehnica" University of Timisoara during 2008-2010. I took the dissertation exam in June 2010 and passed it with grade 10.

Between 2010-2013, I attended the courses of the **Doctoral School** of the Faculty of Management in Production and Transport in Timișoara, Project no. 77265 Contract POSDRU/CPP107/DMI1.5/S/77265: "Towards research careers through doctoral studies", project manager prof. univ. dr. eng. Gheorghe-Daniel ANDREESCU. The doctoral thesis is in the field of Engineering and Management, entitled "Contributions on risk management in sustainable enterprise", conducted under the guidance of prof. univ. dr. eng. Monica IZVERCIAN. The public support of the doctoral thesis took place on September 20, 2013 (confirmed by OMEN 5581 / 03.12.2013) with the very good qualification. During the doctoral research, in 2012 I carried out my doctoral internship in Hochschule Karlsruhe - Technik und Wirtschaft, Karlsruhe, Germany.

In 2013, I graduated the two levels of the program of psycho-pedagogical training within the Department of Training of the Teaching Staff, the Polytechnic University of Timisoara. I have promoted both modules with grade 10.

I made my debut in the economic environment in 2002, when I also took my baccalaureate exam. From 2002 to 2010, when I started my doctoral training, I worked as a

programmer in various companies. The accumulated knowledge in the field of management and sustainability contributed to my collaboration with companies from the business environment for the development of different reports (*Action plan on sustainable energy, Strategies developed for different cities in Romania, Foundation studies, Studies on the impact of projects on certain regions, marketing strategies and others*). This experience contributed to my professional development as a support for connecting the theory with the real applicability, in the business environment.

The debut in the didactic activity took place in October 2013 (the academic year 2013/2014) at the Faculty of Management in Production and Transport, Politehnica University Timișoara, having the opportunity to guide the students from year III, the field of Engineering and Management, to the activity from the seminar from the discipline "Marketing". The seminars are systematized, solidly argued, being especially appreciated by the students of the faculty who have registered an active participation in the seminars. During the seminars I tried to motivate the students to conversations on topics and practical examples correlated with the topics addressed in the course. The evaluation mode chosen for the seminar was the project, considering that this form of evaluation entails the student's ability and knowledge to harmonize the various concepts learned during the semester with the requirements of the economic environment.

The activity as a university assistant continued with the same dedication and attachment to the students and the academic environment. In 2013 and so far I coordinated the activities from the seminar and seminar works for the disciplines: Marketing, Human Resource Management, Sustainable Development applied in the logistics systems and Sustainability and Risk. During these years I managed to pass on the knowledge to the students and the masters in an appropriate manner accepted and appreciated by them.

Starting with 2017 I continued my activity as head of works, being the holder of the disciplines Sustainable development applied in the logistics systems and Sustainability and Risk. From 2017 and until now I coordinate the activities from the seminar and project for the disciplines Marketing 1, Human Resource Management, Strategic Management (at the master's cycle) and Strategic Management (in English, at the master's degree).

Starting with 2013 we had the opportunity to coordinate students from the license. Being their dean of the year I managed to:

- motivate a number of students who were inclined to drop out of college.
- actively involve in the process of teaching-learning the students who presented a decline.
- have a permanent connection with the year coordinator and the group coordinators.
- appreciate the students who managed to promote certain study periods with the grade 10 (ten).
- appreciate the students who have been actively involved in social and cultural issues.
- carry out a series of activities, outside the class hours, which have helped to strengthen the connection between the faculty entity and the group of students.
- carry out various activities through which students self-evaluate, developing each their own development strategy. Thus, students have understood where they are and what they will be able to achieve in the future through a sustained and balanced effort.
- organize charitable campaigns to support rural education.

- involve students in the research activity. Together with the students we published scientific articles in international journals and conferences: Scientific Bulletin of the Polytechnic University of Timisoara (Engineering and Management)- ISSN 2392-7364, Research Hub Journal - ISSN: 2180-0065, Review of Management and Economic Engineering - ISBN 1583-624X, 6th International Management Conference: Performance Management or Management Performance? (RMEE 2018), ISBN 2247-8639, International Business Information Management Conference (33rd IBIMA2019), ISBN: 978-0-9998551-2-6.
- involve students in the development of software applications for the EcosEc lab.

All these coordination activities I carry out as dean of the year at the master's cycle and as a teacher.

I commit myself to continue these activities also in the current academic year, showing the same involvement and dedication.

I got involved in coordinating the students who participated in the Student Circle in the field of Engineering and Management in the years 2015, 2016, 2017 and 2018. The coordinated students have significant results for the field of Engineering and Management, as follows:

- 3nd Prize (2018) within the manifestation "National scientific competition in the field of Engineering and Management, Prof. dr. eng. Moise Țuțurea", the Marketing section, organized by the Transilvania University of Brașov - coordinating the student work;
- 2nd Prize (2017) within the manifestation "The Student Circle in the field of Engineering and Management, organized by the University "Aurel Vlaicu" from Arad" - coordinating the student work;
- 1st prize (2016) within the manifestation "The Student Circle in the field of Engineering and Management from Bacău, Vasile Alecsandri University" - coordinating the student work;
- 1st prize (2015) within the manifestation "The Student Scientific Circle in the Field of Engineering and Management" Prof.univ.dr.eng. Moise Țuțurea "from Constanța" - coordinating the student work. At the same time I got involved in activities to promote our faculty.

At the same time, starting with 2017, I have carried out humanitarian campaigns to support education in rural and urban areas, coordinating the actions:

- „This year, Be You Santa (2017)" – 1st edition entitled" Support for abandoned children",
- „This year, Be You Santa (2018)" - the second edition entitled "Education in rural areas",
- „This year, Be You Santa (2019)" - the third edition entitled "The joy of learning for village children",
- „For Easter, give joy (2019)" - 1st edition entitled "A book for the future".

I participated in various activities within the FMPT, as follows:

- I was the secretary of the commission to support the dissertations
- I was the secretary of the commission "Session of student communications"
- I participated in the admission process to the license cycle - July and September sessions

- I participated in the admission process to the master cycle - July and September sessions.
- I accompanied the students to different study visits made in Timișoara, Craiova, Slatina, Gyor.

I participated in various training courses, among which are: Industrial Risk Management, Business Customers Communication, Process Manager and others.

A2. The present didactic approach:

The didactic approach will be student-centered, using methods appropriate to the field and creating teaching materials that will support it in order to train the skills necessary to be able to profess as specialists in companies in the business environment.

The didactic activity is based on the three directions systemized in:

1. *How should it be done?* - which are the tools, methods, technologies, marketing programs, reporting standards, the most suitable and topical programming languages used by companies in the business environment
2. *What should be done?* - what are the directions to be followed for the training of future professionals
3. *Why should it be done?* - to increase the employability of students and masters in companies in the graduate field.

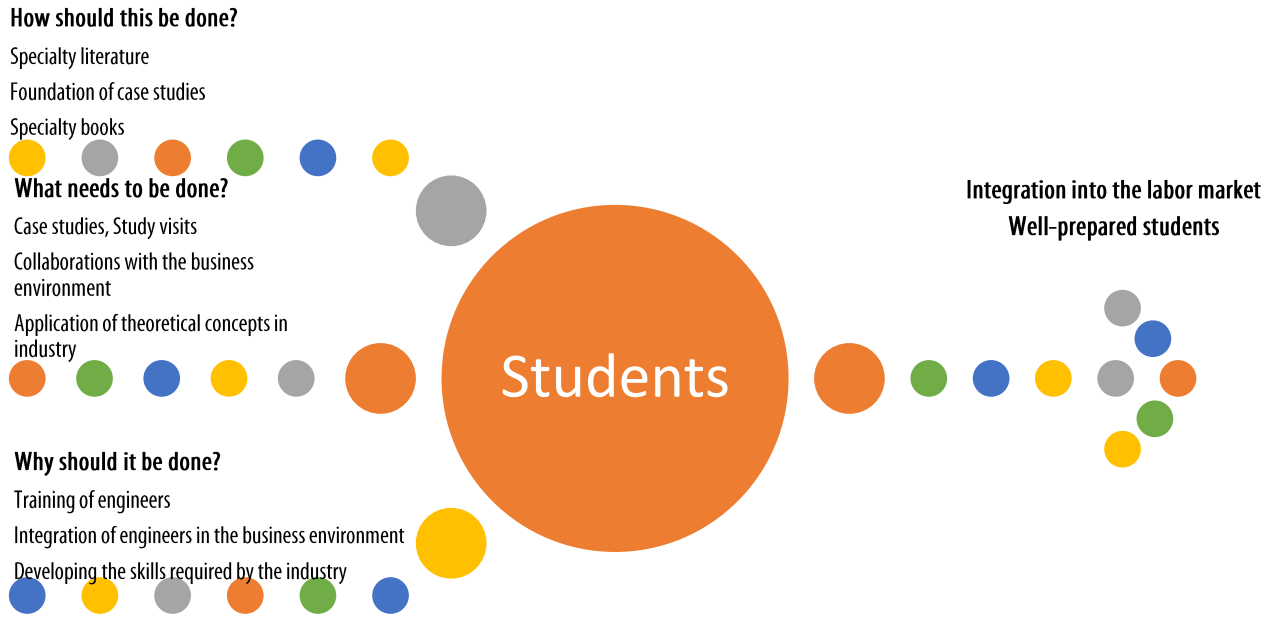


Figure 2.1. The directions targeted in the didactic activity

The domains studied so far that represent the support of my research are shown in figure 2.

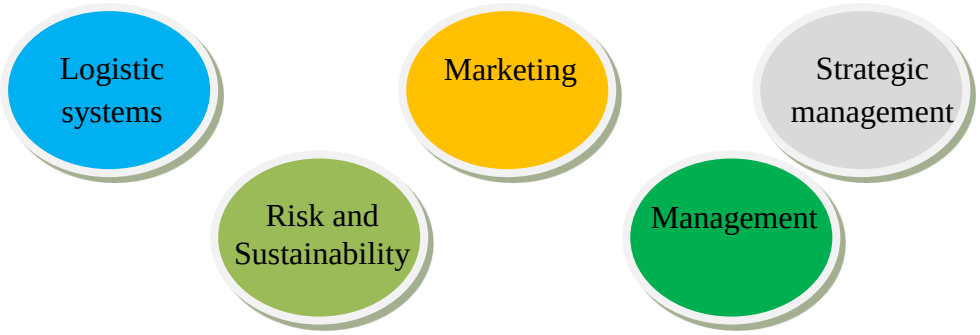


Figure 2.2. Domains studied

The areas studied represent the present and future directions of interest. These fields are the basis of the scientific research and the results obtained so far.

A3. Career Development Proposals:

Career development follows the three defining directions: applied research, individual study and collaboration with the business environment.

In this regard, I will try to develop collaborations with various companies. I will also emphasize the collaboration with regulatory associations and organizations - in the field - at national level, I will seek to develop new partnerships with similar universities at home and abroad, with research institutes and with industry both locally and nationally and with external partners (universities, research institutes, other bodies in the field).

The didactic activities will be continued as until now, with the continuous updating of the materials provided to the students, by integrating the new technologies and concepts that appear, with the extension of their competences, and by collaborating with various companies I propose the development of the didactic curriculum and the initiation of new research programs and establishing new partnerships, in which to attract more students to research work and teamwork, so that they can more easily integrate into the labor market at the end of their studies.

Specifically, in the future, I propose the following:

- Continuously updating the teaching materials with the new trends in the field.
- Publication of a didactic manual for the sustainable development of companies
- Different study visits in companies
- Involvement and development of voluntary activities
- Coordinating students in teaching and learning activities
- Coordination of students in the license work
- The guidance of the PhD students and their support in the research activity
- Use of real case studies to increase students' capacity for analysis and creativity

The activities, in the future, will focus on three main directions: the didactic activity, the research activity and the further increase of the professional prestige.

The didactic activity will be reflected through specialized teaching materials, manuals, laboratory / seminar papers, in which I will be involved, as well as the interaction with students and their involvement in various activities that lead to their professional training. I will try to develop a balanced coordination of future license and dissertation work.

2.2. RESEARCH ACTIVITY

B1. The results of the research activity so far

I supported my PhD thesis on September 20, 2013, being confirmed by OMEN no. 5581 of 03.12.2013. The topic of the doctoral thesis is located at the intersection of the risk assessment with the sustainable enterprise. During the doctoral research, in 2012 I carried out my doctoral internship in *Hochschule Karlsruhe - Technik und Wirtschaft, Karlsruhe, Germany,* thus developing the opportunity to collaborate with professors from abroad.

The research activity has two major dimensions: participation in research or consulting projects and participation in different scientific events.

During this period (2017-2020) I was **director / member in the following projects**:

1. Member (responsible for process, COR code 242104, and trainer, COR code 242401) of the POCU Project "Secure your future through education and entrepreneurship - AVEA"
2. Director of a research contract GNaC2018 - ARUT, no. 1359 / 01.02.2019, in 2019;
3. Director of a mobility contract PN-III-P1-1.1-MC2018-0582, in 2018;
4. Director of a mobility contract PN-III-P1-1.1-MC2017-0706, in 2017;
5. Member of the project 16182 / 21.11.2017, entitled "Research and teaching laboratory" Lean and sustainability"
6. Member of the project BC 31 / 29.03.2019, entitled "Services for carrying out A study on the impact analysis at the region level of the supported businesses".
7. Member of the project BC 29/02.04.2018, entitled „Elaboration of documentation in order to update the strategic development plan of SN AIT-TV SA".
8. Member of the project 2018-1-RO01-KA204-049253, entitled „Teaching and Educating for Sustainability – TeachSUS".
9. Member of the project CNFIS_FDI_2019_0690, entitled „Making a flexible manufacturing line for simulating entrepreneurial activities in the productive field".
10. Coordinator of a scientific work within the Academy of Scientists of Romania.

As of 2010, I have elaborated **170 scientific articles**. During 2015 and so far I have contributed to the elaboration of **66 scientific articles**, of which 27 are **indexed by Thomson Reuters** and 39 are indexed in other international databases.

A selection of journal publications is presented below:

- Feniser Cristina, Burz Gheorghe, Mocan Marian, **Ivascu Larisa,** Gherhes Vasile, Otel Calin Ciprian, The Evaluation and Application of the TRIZ Method for Increasing Eco-Innovative Levels in SMEs, Sustainability Jurnal, vol. 9(7), ISSN 2071-1050, pp. 1125, doi:10.3390/su9071125, (FI=1,789) indexed ISI - **yellow zone Q2 quartile**, in 2017 .

- Cioca Lucian-Ionel, **Ivascu Larisa**, Risk Indicators and Road Accident Analysis for the Period 2012–2016, Sustainability Jurnal, vol. 9 (9), ISSN 2071-1050, article number 1530, WOS:000411621200037, doi: 10.3390/su9091530, (FI=1,789), **yellow zone Q2 quartile**
- Ilie Mihai Tăucean, Matei Tămășilă, **Larisa Ivascu,** Șerban Miclea, Mircea Negruț, Integrating Sustainability and Lean: SLIM Method and Enterprise Game Proposed, Sustainability 2019, 11(7), pp. 2103; impact factor =2,075, https://doi.org/10.3390/su11072103, **yellow zone Q2 quartile**, in 2019.
- Cioca Lucian-Ionel, Ivascu Larisa, Turi Attila, Artene Alin, Găman G. Artur, Sustainable Development Model for the Automotive Industry, Sustainability Journal, ISSN 2071-1050, vol. 11(2), pp. 6447, **factor de impact = 2.592, yellow zone Q2 quartile**– indexed Web of Science

- **Ivascu Larisa,** Cioca Lucian-Ionel, Occupational Accidents Assessment by Field of Activity and Investigation Model for Prevention and Control, Safety Journal, Special Issue Design and Development of Safety Production Management, ISBN 2313-576X, vol. 5(1), pp. 12, https://doi.org/10.3390/safety5010012. Web of Science indexed
- Lucian-Ionel Cioca, **Larisa Ivascu**, Szekely Szilard, Challenges and opportunities associated with waste recycling development in Romania, (8th Edition - International Multidisciplinary Symposium "UNIVERSITARIA SIMPRO 2018" (SIMPRO2018) - „Challenges and Opportunities for Sustainable Development through Quality and Innovation in Engineering and Research Management"), Quality-Access to Success Journal, ISBN 1582-2559, pp. 223-228, 11-13 october 2018, Petrosani, Romania. Web of Science indexed
- Dufour Corina, **Ivascu Larisa**, Mateescu Adrian, Draghici Anca, A propose inventory of sustainable development indicators for the manufacturing processes assessment, (8th Edition - International Multidisciplinary Symposium "UNIVERSITARIA SIMPRO 2018" (SIMPRO2018) - „Challenges and Opportunities for Sustainable Development through Quality and Innovation in Engineering and Research Management), Quality-Access to Success Journal, ISBN 1582-2559, pp. 253-258, 11-13 october 2018, Petrosani, Romania. Web of Science indexed
- Taucean Ilie M., **Ivascu Larisa**, Miclea Serban, Negrut Mircea, Synergies between Lean and Sustainability: A Literature Review of Concepts and Tools, (8th Edition - International Multidisciplinary Symposium "UNIVERSITARIA SIMPRO 2018" (SIMPRO2018) - „Challenges and Opportunities for Sustainable Development through Quality and Innovation in Engineering and Research Management"), Quality-Access to Success Journal, ISBN 1582-2559, pp. 559-570, 11-13 october 2018, Petrosani,Romania.

For the years 2018-2019 I was **guest editor** of a prestigious journal in the field of Engineering and Management, the journal Safety (ISSN 2313-576X), the volume "Design and Development of Safety Production Management", indexed by Clarivate Analytics, http://www.mdpi.com/journal/safety

For the years 2020-2021 I am a **guest editor** of Resources Journal for the special issue Renewables Application: Challenges and Perspectives, indexat Clarivate Analytics, ISBN

2079-9276, Switzerland, indexed by Clarivate Analytics, available online at https://www.mdpi.com/journal/resources/special_issues/renewables_application

For the years 2020-2021 I am a **guest editor** of Safety Journal for the special issue Ergonomics and Sustainability, ISBN 2313-576X, Switzerland, indexed by Clarivate Analytics, available online at https://www.mdpi.com/journal/safety/special_issues/Ergonomics_Sustainability

So far, I am registering over 780 citations of published scientific papers (h-indexClarivate Analytics = 9, h-index Google scholar = 10 , i_{10}Google Scholar = 10, h-indexSCOPUS = 5).

The main **scientific contributions** to the specialized literature, highlighted in the research activity are the following:

- Development of an EcosEc software application for organizational capacity regarding sustainable development being used in laboratories.
- Evaluation of the involvement in the sustainable development of companies at national and global level and the development of an evaluation template.
- Development of a template for social audit.
- Development of models and templates for risk assessment.
- Formulation of directions for the reduction of greenhouse gases at national level.
- Evaluation of the risks of road accidents at the level of Romania and proposing a framework for improvement.
- The assessment of the risks of work at the level of Romania and the proposal of a framework for improvement.
- Formulation of strategies for increasing organizational capacity for sustainable development.
- Carrying out different analyzes in the field of risk, sustainability, marketing, logistics and strategies.
- Strengthen relations on the possibility of developing research partnerships with Singapore, China and Thailand through coordinated mobility projects.
- Strengthening relations regarding the conclusion of mobility agreements with the University of Trento and Insubria University in Italy.

I am a **member of professional associations**:

- Vice President of the Society for Ergonomics and Work Environment Management, Timisoara;
- Member of the International Economics Development and Research Center (IEDRC);
- Member of the Romanian Academic Management Society (SAMRO);
- Member of the Center for Research in Engineering and Management (CCIM).

I am a **member of the editorial boards** or **reviewer** for various scientific events (selection):

- 2020 - reviewer for Journal of Cleaner Production, indexed Clarivate Analytics, impact factor 6,395; ISSN 0959-6526;

- 2020 - reviewer for Energies, indexed Clarivate Analytics, impact factor 2,702; ISSN 1996-1073;
- 2020 - reviewer for Knowledge Management Research & Practice, indexed Clarivate Analytics, impact factor 1,583; ISSN 1477-8246;
- 2020 - reviewer for the Journal of Environmental Management, indexed Clarivate Analytics, impact factor 5,647; ISSN 0301-4797;
- 2020 - reviewer for Innovation: The European Journal of Social Science Research, indexed Clarivate Analytics, impact factor 1.055; ISSN 1351-1610;
- 2020 - reviewer for Air Quality, Atmosphere & Health, indexed Clarivate Analytics, impact factor 2.297; ISSN 1873-9318;
- 2020 - reviewer for Processes Journal, indexed Clarivate Analytics, impact factor 1.963; ISSN 2227-9717;
- 2020 - reviewer for the International Journal of Environmental Research and Public Health, indexed Clarivate Analytics, impact factor 2.468; ISSN 1661-7827;
- 2020 - reviewer for Journal of Sensors, indexed Clarivate Analytics, impact factor 2.024; ISSN 1687-7268;
- 2020 - reviewer for the International Journal of Production Research, indexed Clarivate Analytics, impact factor 3.199; ISSN 0020-7543;
- 2020 - reviewer for the International Journal of Climate Change Strategies and Management, indexed Clarivate Analytics, impact factor 0.92 (Q4), ISSN 1756-8692
- 2019 - reviewer for the journal Waste Management, Impact Factor: 3,829; SJR: 1,764; ISSN 0956-53;
- 2019 - reviewer for Technology Analysis & Strategic Management, indexed Clarivate Analytics, impact factor 1.49; ISSN 0953-7325;
- 2019 - reviewer for the journal Sustainability, indexed Clarivate Analytics, impact factor 2,075, ISSN 2071-1050;
- 2019 - reviewer for the Journal on Efficiency and Responsibility in Education and Science, indexed Clarivate Analytics, Impact factor 2,075, ISSN 1803-1617;
- 2019 - reviewer for Journal of Advanced Transportation, indexed Clarivate Analytics, impact factor 1983 (Q2), ISSN 0197-6729
- 2019 - reviewer for the International Journal of Climate Change Strategies and Management, indexed Clarivate Analytics, impact factor 0.92 (Q4), ISSN 1756-8692
- The 8th International Conference on Business, Management and Governance, Perth, Australia (Technical Committee);
- International Journal of Information Science and Intelligent System (Editorial Board Members)

- International Journal of Social Computing and Cyber-Physical Systems, ISSN print: 2040-0721 (Editorial Board, 2015-prezent)
- International Conference on Marketing, Management and Economics;
- Scientific Bulletin of Politehnica University of Timisoara - Transactions on Engineering and Management, ISSN 2392-7364 (Editorial Office; 2015 – prezent)
- International Conference on Social, Education and Management Engineering (International Scientific Committees, 2017)
- Research Hub, ISSN 2071-1050;

From the perspective of the collaborations with teachers and researchers from the country and abroad, I would like to underline the support offered by:

- Prof. Muddassar Sarfraz (Nanjing University of Information Science and Technology, PR China),
- Prof. Syed Ghulam Meran Shah (Department of Management Sciences, Government College University, Lahore, Pakistan),
- Prof. Ilknur OZturk (Faculty of Economics and Administrative Sciences, Cag University, Mersin, Turkey),
- Prof. Elena Magaril (Department of Environmental Economics of Ural Federal University, Russia)
- Prof. Dr. Eng. Lucian-Ionel Cioca ("Lucian Blaga" University, Faculty of Engineering, Sibiu, Romania),
- Dr. Elena Cristina Rada (Theoretical and Applied Science Department , Insubria University, Italy),
- Prof.dr. Marco Ragazzi (Department of Civil, Environmental and Mechanical Engineering, University of Trento, Italy),
- Prof.dr. Vincenzo Torretta (Università degli Studi dell'Insubria, Italy).

The awards and distinctions received during 2017-2019 are:

- 2018 – Certificate of honor for outstanding scientific contribution, effort and support at the SIMPRO2018 International Multidisciplinary Symposium, University of Petroșani, October 11-13, 2018;
- 2017 – awarded with the distinction "Professor Bologna" for the results obtained in the teaching-learning process (students' appreciation)
- 2019 - UEFISCDI award for research results with the paper „Integrating Sustainability and Lean: SLIM Method and Enterprise Game Proposed" (yellow area, Q2 quartile).
- 2017 –UEFISCDI award for research results with the paper „Risk Indicators and Road Accident Analysis for the Period 2012-2016" (yellow area, Q2 quartile).

- 2017 –UEFISCDI award for research results with the paper „The Evaluation and Application of the TRIZ Method for Increasing Eco-Innovative Levels in SMEs" (yellow area, Q2 quartile).

B2. Future research activity

The research activity will be based on the continuation of the elaboration of scientific studies, scientific works and the development of proposals for national and international calls related to the experience held.

In the future the development of the research activity is focused, as until now, on the participation in international and national specialized events, by publishing and disseminating the research results and by collaborating and developing new methods and results in the field in research projects. More specifically, in order to increase the relevance and impact of my scientific work in the future, I propose the following:

- Publication of two (2) articles per year in Thomson Reuters indexed scientific journals in the field of Engineering and Management.
- Publication of a minimum of five (5) articles per year indexed by Thomson Reuters or other databases.
- Participation in relevant scientific events.
- I will involve the students in the research activity by publishing at least 2 articles per year.
- Publication of a specialized book in the area of sustainable development applied in logistics systems.
- Publication of a teaching book in the field of sustainable development.
- Supporting the empowerment thesis.
- Participation in national and international research networks.
- Participation as a member in 2 research grants with international or national funding.
- Application for obtaining 1 research grant with international funding, as project manager
- Continuing collaboration with various companies in the business environment to apply the concepts and approaches developed.
- Involvement in organizing national and international scientific events
- Completion of the researches already carried out by validating the results obtained in scientific manifestations
- Maintaining / increasing the number of scientific papers published in quality international journals and conferences (indexed Web of Science))
- Honest representation of the Polytechnic University within the scientific manifestations by presenting high quality works with relevant results.

- Intensifying collaboration with St. John Fisher College, Rochester, New York, University of Trento and Insubria University.
- Continuing the research in the fields: risk, sustainability, marketing and management.

I also want to intensify my research activity within interdisciplinary, international research teams close to the individual research fields.

In all my professional activity I rely on the support of the group and the department of which I am part, who has always been with me and has supported me, and not least, my family, who has supported me in all the actions so far.

I will be able to build an excellent academic and professional career, based on honesty, transparency, honesty and a lot, a lot of work, to ensure success and professional fulfillment and an increased visibility of both myself and the department of which I am part and of the Polytechnic University of Timisoara, both in the country and in the world. I appreciate and rely on feedback because it is the way I am evaluated and I will evaluate. This is the framework for continuous improvement.

In order to increase *professional prestige*, I will continue to try to attend important national and international conferences and will also publish relevant and current studies that will record new citations in the specialized literature by their high quality. I will also take the necessary steps to become a member of as many bodies and organizations in the country as well as abroad.

2.3. Administrative responsibilities

I participated in various activities within FMPT, as follows:

- Dean of the year for master's programs (2019 - present) and bachelor's degree (2014-2018).
- Coordination and endowment of the EcosEc laboratory (room M105).
- Development and administration of the faculty website during 2013-present.
- I was the secretary of the dissertation committee, and doctoral committee.
- I was the secretary of the "Student Communications Session" committee.
- I participated in the admission process to the bachelor's cycle - July and September sessions.
- I participated in the admission process to the master's cycle - July and September sessions.
- Member of the organizing team of the "MPT Days" event.
- Member of the bachelor / master programs.
- Member of the board of the Management Department (http://mpt.upt.ro/departament/componenta-departamentului.html)
- Administrator for the website of the Faculty of Management in Production and Transport, www.mpt.upt.ro (2013-present).
- Involvement in accreditation activities and registration of new qualifications in RNCIS (2015-present).

The author was a **co-organizer of international scientific conferences**:

- Member of the organizing committee of the International Management Symposium (SIM 2019).

- Member of the organizing committee of the International Conference on Ergonomics and Workplace Management (ErgoWork 2020).

In the future I intend to:

- Involvement in various activities at the level of the entity
- Continuation of the activity as dean of the year at the master programs
- Encouraging students to participate in projects (new ideas!)
- Website administration and proposal of an efficiency methodology.
- Continuing to organize charitable actions with students
- Promoting the faculty based on a strategy
- Involvement of students in the promotion of the faculty
- Involvement in organizing conferences / debates / workshops
- Attracting new companies for collaboration
- Involvement in the event "MPT Days" - future editions by proposing new attractive sections.

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Appendix – 10 Papers considered by the candidate to be the most relevant (Anexa – 10 lucrări considerate de către candidată ca fiind relevante)

1. **Ivascu Larisa,** Measuring the implications of the sustainable manufacturing in the context of industry 4.0, Processes Journal, ISSN 2227-9717, vol. 8 (5) pp. 585, impact factor 2.753, Q2 quartile, 2020.
2. Shah, Syed Ghulam Meran*, Sarfraz Muddassar, **Ivascu, Larisa*,** Assessing the Interrelationship Corporate Environmental Responsibility, Innovative Strategies, Cognitive and Hierarchical CEO: A Stakeholder Theory Perspective (Accepted and In Press) Corporate social Responsibility and Environmental Management, ISBN 1535-3958, factor de impact 4.542, Q1 quartile (acceptata, in curs de publicare).
3. Sarfarz Muddassar, Shah, Syed Ghulam Meran*, **Ivascu, Larisa,** Qureshi, M.A.A. Explicating the impact of hierarchical CEO Succession on SMEs Performance and Cash Holdings (Accepted & In Press) International Journal of Finance and Economics Wiley, ISBN 1099-1158, factor de impact 0.943, Q4 quartila, (acceptata, in curs de publicare).
4. Tamasila, M., Prostean, G., **Ivascu, L.*,** Cioca, L.I., Draghici, A., Diaconescu, A., Evaluating and prioritizing municipal solid waste management-related factors in Romania using Fuzzy AHP and TOPSIS, Journal of Intelligent & Fuzzy Systems, ISBN 1064-1246, pp. 1-18, vol. 38(5), pp. 6111-6127, impact factor 1.637, Q3 quartile, 2020.
5. Dufour Corina, Draghici Anca, **Ivascu Larisa *,** Sarfraz Muddassar, Occupational Health and Safety Division of Responsibility: A Conceptual Model for the Implementation of the OHSAS 18001:2007 Standard, Human Systems Management Journal, ISBN 1875-8703, (in process of publication), 2020.
6. Cioca, L.I., **Ivascu, L.*,** Turi, A:, Artene, A., Găman, G.A., Sustainable Development Model for the Automotive Industry, Sustainability Journal, ISSN 2071-1050, vol. 11(2), pp. 6447, 2.592 impact factor, Q2 quartile, 2019.
7. **Ivascu Larisa*,** Cioca Lucian-Ionel, Occupational Accidents Assessment by Field of Activity and Investigation Model for Prevention and Control, Safety Journal, Special Issue Design and Development of Safety Production Management, ISBN 2313-576X, vol. 5(1), pp. 12, https://doi.org/10.3390/safety5010012, 2019.
8. Ilie Mihai Tăucean, Matei Tămășilă, **Larisa Ivascu*,** Șerban Miclea, Mircea Negruț, Integrating Sustainability and Lean: SLIM Method and Enterprise Game Proposed, Sustainability Journal, 2019, vol. 11(7), pp. 2103; 2.075 impact factor, Q2 quartile https://doi.org/10.3390/su11072103
9. Cioca Lucian-Ionel, **Ivascu Larisa***, Risk Indicators and Road Accident Analysis for the Period 2012–2016, Sustainability Journal, vol. 9 (9), ISSN 2071-1050, article number 1530, doi: 10.3390/su9091530, 1.789 impact factor, Q2 quartile.
10. Cioca Marius, **Ivascu Larisa*,** Cioca Ionel-Cioca, Safety Performance Indicators in the Metallurgical Industry Using Web Programming, Metalurgija Journal, Vol. 56, issue 1-2, ISSN 0543-5846, pp. 272-274, 0.959 impact factor, Q2 quartile, 2016.

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