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Carbon footprint assessment within the Romanian manufacturing sector

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Abstract. The paper presents the results of a survey performed upon 83 Romanian companies, most of them in the manufacturing sector, with respect to their preoccupations and initiatives related to sustainability, and especially becoming active players in envisioned the low carbon economy. We conclude that there are promising signs of change and that continued support is needed in the future for companies to undergo the needed transformations to their processes and product development undertakings.

Keywords. carbon footprint, manufacturing sector, production

1. Introduction

Romania is one of the 195 countries that signed the Paris Agreement in 2015. The text of this agreement requires every country to adopt a sustainable development strategy (European Commission, 2019). The strategy is supposed to realize the main objective of the agreement, which is to prevent an increase of global average temperature of more than 2°C above the average temperature of the pre-industrial Earth, and, if possible, bring that limit down to 1.5°C before the end of the current century (European Commission, 2019).

In addition, the European Union has adopted a package of measures more ambitions than those in the Paris Agreement, called the European Green Deal (European Commission, 2020), and Romania, being a member of the European Union, must align to these measures, whose main goal is for Europe to become neutral by 2050 in terms of greenhouse gas (GHG) emissions. GHGs are composed of water vapor, carbon dioxide, methane, nitrogen oxide and ozone, with CO₂ being the gas that most favors global warming because it prevents heat generated by the light from the Sun to leave the atmosphere (European Commission, 2020).

To investigate the approach to carbon footprint determination and environmental regulations, the authors have conducted a survey for Romanian companies, mainly from manufacturing sector. Through a questionnaire, the objective was to find out for each

respondent what is the company's attitude regarding the carbon footprint, what are the measures currently applied and how the stakeholders are involved in reducing the CO₂ emissions.

2. Literature review

The Low carbon economy is a trendy topic in the last few years. In the following table, we will present other important papers which add valuable contributions to carbon footprint theoretical or empiric investigations.

Scientific content	Source
In this paper the policies and the strategies used by UK in the automotive manufacturing processes in order to increase the energy efficiency are described. The main topics of interest are represented by: energy consumption, waste production, water consumption, and air quality.	(Giampieri, Ling-Chin, Taylor, Smallbone, & Roskilly, 2019)
The survey of this paper has the purpose to study if the cleantech firms are interested in expanding their operation in low carbon cities. There are presented the benefits of the low carbon cities and their efforts to attract R&D centers. The conclusion of the study is that even if low carbon cities present many benefits, the firms are mostly in disagreement with the relocation of their activities.	(Kapsalyamova, Mezher, Al Hosany, & Tsai, 2014)
This paper proposes four low carbon approaches for the machine building industry in order to improve energy usage, operational efficiency and reduce carbon emissions, all in line with a low carbon manufacturing sector.	(Yanbin, Qian, Congbo, & Lan, 2015)
This paper is analyzing the relation between optimal pricing and the decision of emission reduction in the context of a competitive market for two rival manufacturers. The decision science analysis is performed using game theory. The authors also discussed the impact of production and carbon emission reduction efficiencies.	(Xu, Zheng, & Xiaojun, 2017)
The carbon footprint of common household activities is analyzed in this paper that investigates the sustainable consumption of a household, its impacts on the environment and the possibilities to influence individual consumption patterns.	(Smetschka, et al., 2019)
This paper structures a review of literature in the field on sustainability dimensions and sub-dimensions. The aim is to find what are the sub-dimensions that can contribute to the creation of a sustainable manufacturing sector.	(Eslami, Dassisti, Lezoche, & Panetto, 2019)

3. Data collection and results

In this work, a questionnaire regarding the relationship of firms with the environment, the regulations applied, and the measures taken by companies concerning the carbon footprint has been developed and applied. Data collection was performed during October-November 2020. The method used for achieving the questionnaire have been mostly the semantic differential which measures the opinion/appreciation intensity in connection with a certain stimulus.

The questionnaire contains 40 questions which are divided in 3 sections. In the first section, the aim is to find out the relationship between the company and the environment. This section contains 9 questions. The second section includes issues related to regulations and legislation applicable regarding the company's carbon footprint. This section contains 8 questions. The third section contains 18 questions regarding the measures taken and their effectiveness in reducing the carbon footprint.

The questionnaire was applied for 83 companies, of which 80% of them are from the manufacturing field, especially automotive components, furniture production, and metal processing, while 20% are companies from related fields, such as services, consulting, training, and others. In the figure 1, below, is shown the percentage for each field that responded to the

questionnaire. Automotive components represent 33% of the respondents, furniture production 14% of the responds, metal processing 17% of the responds and the other productions such as plastic parts, appliances, ceramic tiles represent 16% of the respondents (left-hand side).

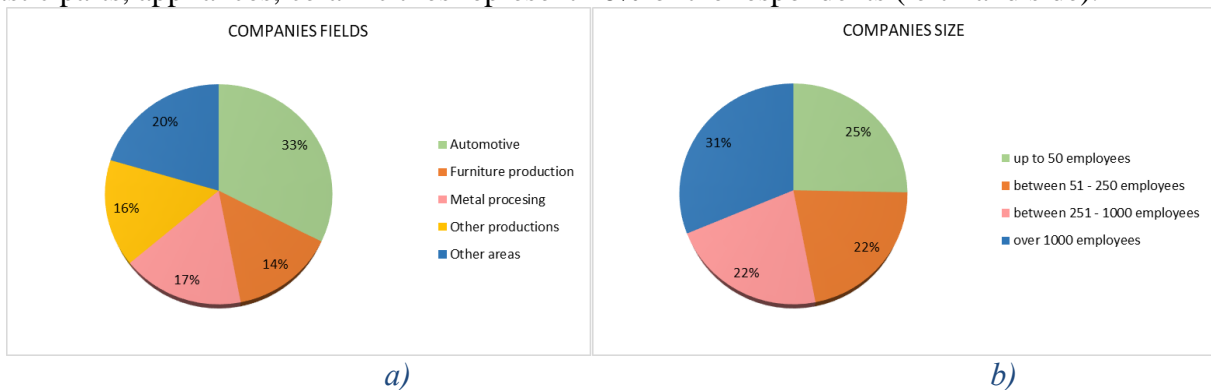


Figure 1 Companies field and size

Regarding the size of the company, an interval scale was used in the questionnaire, in which the companies were grouped as follows: up to 50 employees - small companies, 51-250 employees - medium sized companies, 251-1000 employees - large companies, over 1000 employees - very large companies. The questionnaire was applied to a heterogeneous population of firms in terms of size, as can be seen in figure 1 (right-hand side). The small and medium companies responding to the questionnaire represent 47% of the total responding companies, the difference of 53% being large and very large companies. In this way, without having a complete statistical analysis, we can infer that the respondents to the questionnaire are representative for the studied industry and the findings can be considered relevant and insightful for future studies. The authors consider that continuing this demarche and expanding it will reveal important details for supporting the transformation of Romanian companies in the coming decades.

In the first section of the questionnaire regarding the relationship of the companies with the environment, the top three measures already adopted by them are the selective collection of waste, standardization and improvement of processes and modernization and/or replacement of processing technologies. Over 50% of respondents also selected increased energy efficiency and reduced energy consumption and/or the use of alternative energies (figure 2).

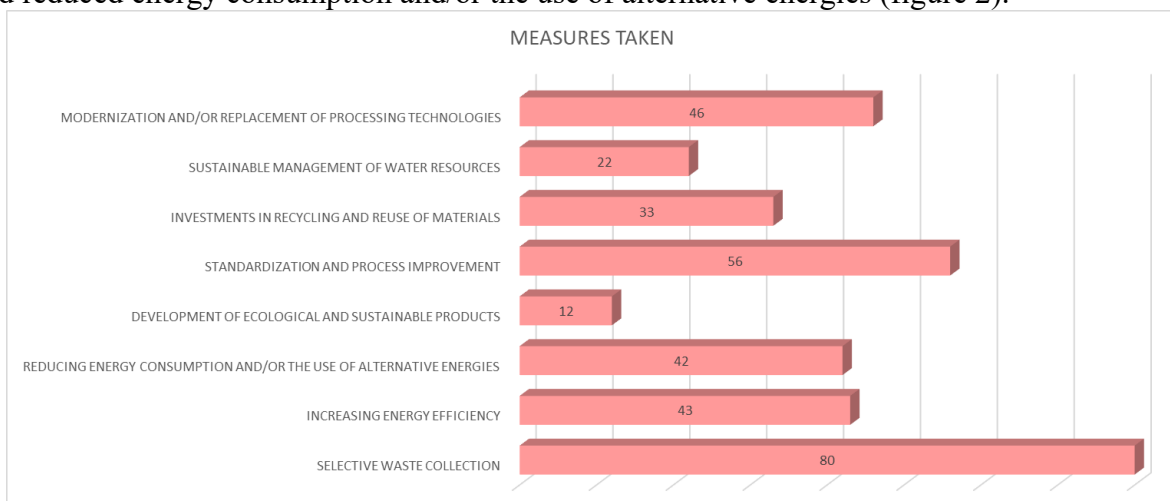


Figure 2 Measures taken already for sustainable development

In the second section of the questionnaire, regarding the legislation and regulation, the most known regulation by respondents is Government Emergency Ordinance 195/2005 on environment protection as is presented in figure 3 below. In terms of relevance of the measures, the Paris Agreement and European Green Deal are considered important to achieve a low carbon footprint. The lack of knowledge of the actions and measures included in these strategic document produces some imbalance in the adherence of Romanian companies to this trend.

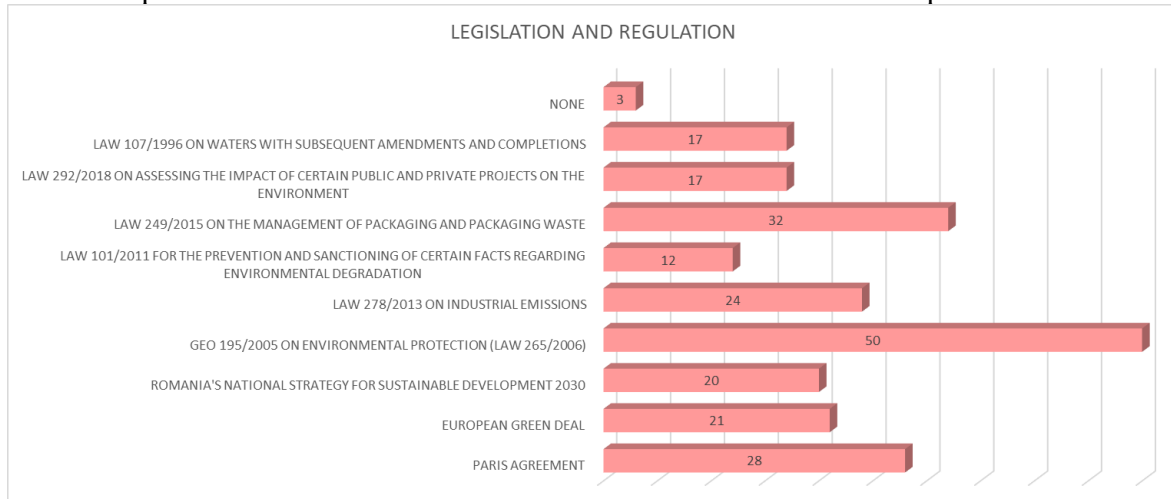


Figure 3 Legislation and regulation observed by Romanian manufacturing companies

In terms of costs for implementing environmental measures, the score obtained by semantic differential (the scale applied is from 1 to 5) is 3.34. This can be interpreted that adopting a healthy ("green") organizational behaviour is not easy for the companies and a sustainable investment is needed for accomplishing concrete results. By adopting this behaviour, 74.7% of the respondents believe that these costs bring added value to the company and it is desirable to invest in them.

Also, concerning financial incentives from the state, 86.7% from respondents said that they did not benefit from any kind of support. However, there are 13,3% who said that they did. There are 14 companies who said that they have benefited from investments in infrastructure / equipment, 7 companies mentioned that they have benefited from tax exemptions and 5 companies that benefited from reduced restrictions.

Overall, the ratio between the costs and the financial incentives from the state is accepted by the companies that want to align with European policies as they need support in making this step even if the help is delayed or the methods to access the incentives are not well known.

In the third section of the questionnaire, the topic was to find out the precise measures and their impact in regard with the reduction of carbon footprint. The main known effects of carbon dioxide on the environment, identified following the application of the questionnaire are: global warming, sea level increase due to the melting of ice caps, as well as the deterioration of the quality of life. Global warming is by far in the first place, with a response rate of 85.5% of respondents.

To find out the availability of the responding companies to invest in technologies and processes with low carbon emissions, there is used the semantic differential with 5 levels (from 1 to 5). Following the analysis, we obtained an average of 3.61 for the answers, a grade that exceeds the average of the interval (which is 3). Thus, we can conclude that companies are not indifferent in terms of carbon footprint reduction and that their intention is to create products and use processes that are as unharmed as possible.

On the same semantic scale, we obtained a grade of 2.75 for the company's reluctance to adopt voluntary environmental protection measures. Although companies are open to "green" investments, they need an additional incentive to adopt such voluntary measures, such as standards and reporting initiatives.

Regarding the measures that companies are willing to take to ensure a low carbon economy, 74.7% said that green technologies are the most appropriate measure (figure 3).

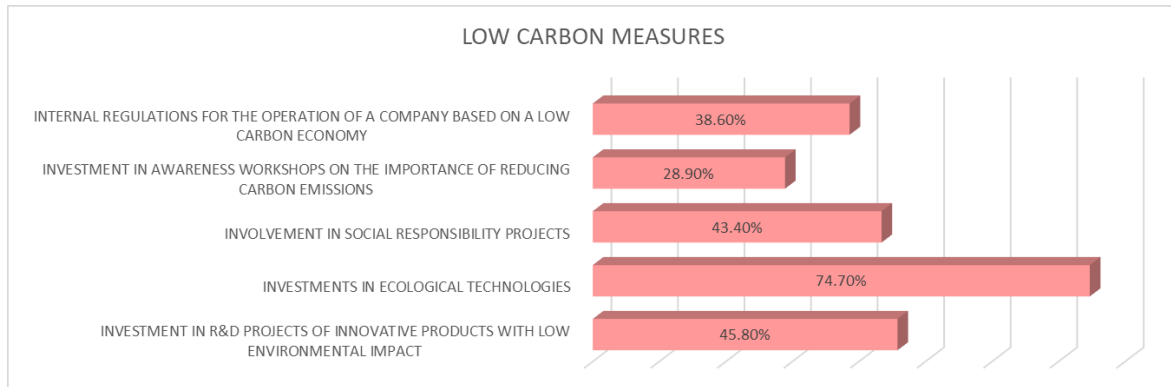


Figure 4 Measures adopted for a low carbon footprint

In terms of the feasibility of this measure, using the 5-level semantic scale, the grade obtained is 3.87. As an interpretation, we can say that investments in ecological technologies is a method wanted by companies and is effective.

4. Conclusion

This survey generates interesting insights. The results obtained show that Romanian regulation and legislation require modifications for applying the actions and measures foreseen by the European Union. The communication between stakeholders like economic agents, government, environmental authorities, universities, R&D centers is insufficient and needs more implication by each side.

Despite this inconvenient, the attitude of the companies is open to embracing a new approach regarding the manufacturing of goods in a manner aimed at reducing the carbon footprint. The possibility to have a sustainable production is not unknown for companies and is also a way that improves the capacity of the company to develop. One of the measures taken by companies is the modernization and replacement of the technologies used in processes in order to become more sustainable. The percentage of companies which implement this measure is slightly above 50%, and we believe that increasing it can be achieved by a coordinated effort of the public and private sectors.

Having an overview about the perspectives of companies from the manufacturing sector is helping determine directions of intervention. Our future work will present the methods and the techniques that can be adopted by companies in order to improve their processes and develop new products in a manner that helps reduce the carbon footprint.

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