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Study of the impact of technological innovations on the sustainable freight transport

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Abstract. When considering the environmental impact of freight transport, the road mode assumes special relevance due to differences in environmental performance, mainly in terms of resource consumption and greenhouse gas (GHG) emissions, in addition to other pollutants and noise. To make freight transport more environmentally sustainable, the European Commission's plan is the Sustainable and Intelligent Mobility Strategy, which aims to sharply reduce transport emissions by 2050. In this sense, technology and innovation should be part of the companies' objectives, to promote sustainable and continued development. This

study was developed with the main purpose of understanding whether road freight transport companies in Portugal use new technologies to adopt a more sustainable environmental behaviour. This research also allowed a better comprehension of the types of investments being made, the main reasons that lead companies to invest in technology, and to understand the main difficulties associated with the adoption of sustainable measures. The data to support this study were collected through an online questionnaire directed to medium and large companies. The answers obtained correspond to 12% of the population. The large and medium-sized Portuguese companies that answered the survey are aware of and are investing in technological innovations with a view to sustainable goods transport. They understand the importance of including sustainable practices in the definition of their strategies, especially in route management and cargo planning and consolidation. Investing in technology is a unanimous strategy used to reduce GHG emissions and the reasons that lead companies to invest are the improvement in environmental performance, cost control and the consequent achievement of competitive advantages. It was highlighted that hydrogen will play a key role in the energy transition because it has storage capacity and flexibility to be used also in various sectors of the economy, being seen as the best solution for heavy duty vehicles.

Keywords: Innovation; Sustainability; Road freight; Energy.

1. Introduction

In today's society, the means of transport play a fundamental role, since the expansion of the exchange of goods and the intensification of world trade have raised the issues of transport and mobility to an increasingly relevant level in people's daily lives, and for this, the existence of an efficient transport network is necessary [1]. However, this whole context of displacement of people and goods has an immense cost in environmental terms, being increasingly urgent to reverse this trend of exacerbated consumption and direct us towards a path of sustainability. This requires the adoption of ambitious measures, which promote and foster the most sustainable means of transport according to each scenario. Facing this scenario, the European Union (EU) has promoted a policy in the transport area aiming at promoting cleanliness, safety and efficiency in order to achieve carbon neutrality by 2050 [2, 3]. The knowledge has always generated economic development, currently, has been fundamental to achieve a more sustainable scenario using new technologies, either in the development of new energy sources (green hydrogen) or in the implementation of new information and communication

technologies (Artificial Intelligence; Machine Learning; Block Chain) in transport. In this context, this work was developed with the objective of understanding, in the Portuguese context, if road haulage companies use new technologies to adopt a more sustainable environmental behavior, responding to the EC Road Map [2]. Therefore, Section 2 presents the main concepts related to Road Freight Transport and Innovation and Technology in Transports. The methodology used for this research is presented in Section 3, and the main results are shown in Section 4. Finally, the main findings and some limitations of the study are portrayed in Section 5.

2. Road Freight Transport

Inevitably, all of today's economic sectors will always depend, to a greater or lesser extent, on the performance and efficiency of the goods transport sector. In this sense, the operationalization of the transport of goods has become a differentiating component of companies in order to build loyalty and ensure customer satisfaction. Similarly, to the world context, road transport of goods in Europe occupies a prominent place, with 75.3% of total terrestrial transport of goods [4], and within this context, Portugal has been one of the European countries that shows greater dependence on this type of transport. According to the Portuguese Environmental Association (APA), from 2021, also in Portugal, road transport dominated land freight transport with a representation of 87% in 2019, well above the percentage verified for the whole EU with 77% [5]. When considering the environmental impact of freight transport, the road mode assumes special relevance due to the differences in environmental performance, mainly at the level of resource consumption and greenhouse gas emissions (GHG), in addition to other pollutants and noise. In this sense, the Strategic Plan for Transport and Infrastructure 2014-2020 was released in 2014, and revised in 2015, which establishes a set of objectives, of which stands out as one of the most ambitious, the increase in the order of 40% of the number of tons per kilometer transported in the railway mode. [6]. Simultaneously to this document, the White Paper on Transport, adopted by the European Commission in 2011, presented a proposal for the transfer of cargo transported to other types of transport, establishing as an objective that by 2030 30% of road freight traffic in distances greater than 300 km should be reduced, and a further 50% by 2050, being carried out with the help of efficient and ecological corridors [6].

2.1. Innovation and Technology in Transports

To achieve the objectives of the European Ecological Pact [2], priority actions are defined as strengthening modal transport, supporting the implementation of automated and connected mobility, and improving external costs by increasing production and

adopting sustainable alternatives [4]. In order to mitigate pollution and gas emissions it is important to implement sustainable transport policies, either through economic instruments or through the use of technologies, always without compromising the mobility of people and goods. The economic instruments may consider the production and purchase of ecologically adequate vehicles or encourage the consumption of more efficient fuels. On the other hand, the use of technological innovations has a fundamental and practical role in the optimization of the entire transport process [7] [8]. In this field, of technology in transport, very significant advances are observed that have provided a global market increasingly interconnected, faster, competitive, and sustainable [9]. An example of this is new technologies that have been widely developed and adopted within the automotive industry, such as electric vehicles (EV), autonomous vehicles (AV), robotics, logistics automation, and artificial intelligence (AI). The idea of technological innovation is directly linked to the industry's digital transformation movement. [10-12].

3. Methodology

This study's main objective was to understand how Portuguese inland freight transport companies deal with technologies and adopt more sustainable behaviors. The research question posed was:

Are Portuguese haulage companies aware of and are they investing in technological innovations with a view to environmental sustainability and the reduction of greenhouse gas emissions?

This study's target population was large and medium-sized Portuguese freight transport companies. The reason for this choice is due to the fact that they have greater economic capacity which translates into the possibility of a better positioning at the level of expressive investments. In Portugal, there are approximately 7,853 goods transport companies of which 103, approximately 1.3%, are considered large and medium-sized companies**. After a fairly exhaustive literature review, it was decided to use the questionnaire as an analysis tool with closed and open questions. This questionnaire was prepared using the Google Forms platform and disseminated via email to the 103 companies that make up the population under study. The respondents were explained the purpose of the study and given an average response time of 10 minutes. The confidentiality of the answers and the anonymity of the respondents were also guaranteed. The questionnaire was divided into 4 sections, with which it is intended to understand:

** https://ec.europa.eu/eurostat/databrowser/view/SBS_NA_1A_SE_R2__custom_5954491/default/table?lang=en

Section 1 - Characterization of the respondent - understand the level of bond and involvement that the individual respondent has with the company;

Section 2 - Characterization of the company - the size of the company in terms of turnover and number of vehicles, type of fleet and geographical location;

Section 3 - Information on strategies and adoption of sustainable measures and practices - the strategies and environmental concerns, drivers and barriers to the adoption sustainable measures;

Section 4 - Positioning of the company with regard to available technological innovations - the importance of new technologies in the company, the value of the investment in technology and the expected return.

4. Results and Discussion

Out of 103 medium and large Portuguese freight transport companies, 12 answered the proposed questionnaire. Following the organization of the 4 parts which make up the questionnaire, the results were as follows.

4.1. Characterization of the companies

Of the 12 respondent companies, 58% are medium-sized companies (50 to 250 employees), with the remaining, large companies, having more than 250 employees. Only one of the 12, the most recent (2014), is dedicated exclusively to national transport. The others provide national and international services and all of them have been operating for more than 25 years in this sector of activity. As far as annual turnover is concerned, the majority, 58.33%, have a turnover between 10 and 20 M€. Only one company presents an annual turnover greater than 50M€. With regard to the annual distance travelled, the most common in this group of companies is between 10 and 20 Mkm, as illustrated in Figure 1.

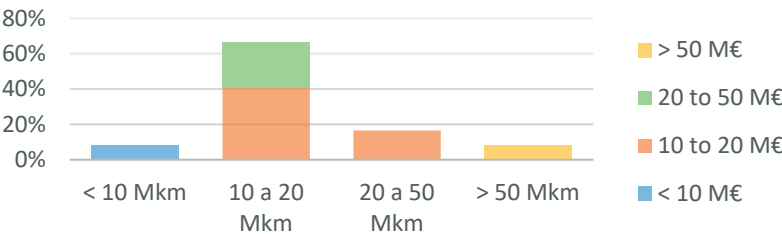


Figure 1 – Annual turnover (M€) according to the annual distance travelled (Mkm)

In terms of geographical location, 41.7% of the responding companies are from the Centre region, 33.3% from the Metropolitan area of Lisbon, 16.7% from the North region, and 8.3% from Alentejo. It should also be noted that two thirds of the responding companies only own heavy vehicles and, of these, half only have their own fleet, as shown in Figure 2 (left). Amongst the companies observed are those which exclusively own heavy vehicles with a fleet varying between 100 and 250 vehicles (Figure 2, right).

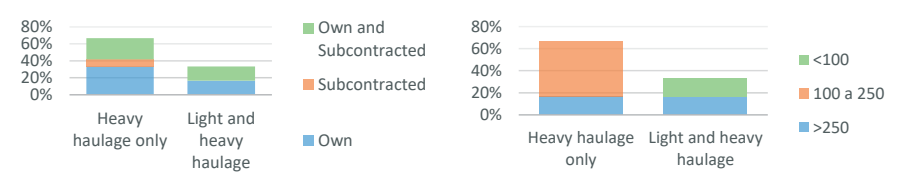


Figure 2- Distribution of fleet type (heavy only or light and heavy vehicles) by category (left) and number of vehicles (right)

4.2. Information on strategies and the adoption of sustainable measures and practices

Most of the Portuguese medium and large haulage companies analyzed (75%) admitted having already developed plans and implemented actions arising from environmental sustainability concerns. The remainder stated that they were in the implementation phase at the time of the questionnaire. It should be noted that none of the responding companies expressed unfamiliarity or lack of interest in the matter. As to the degree of importance attributed to the different sustainable measures in the company’s policies, see Figure 3, the “Reduction of Energy Consumption” was the measure that was given greater importance by the companies. The “Use of renewable fuels”, although important, plays a minor role in the companies observed.

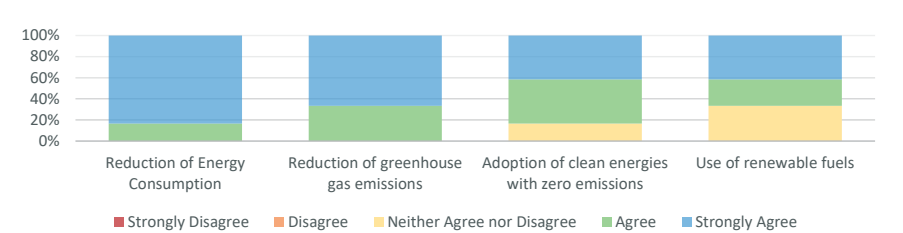


Figure 3 - Degree of importance given to different sustainable measures in the company's environmental policies

When asked about the strategies followed towards the implementation of sustainable measures, most companies attributed special emphasis to the consolidation of loads and the management of transport routes, as can be confirmed in Figure 4. The use of electric or hybrid vehicles assumed less prominence among the respondents.

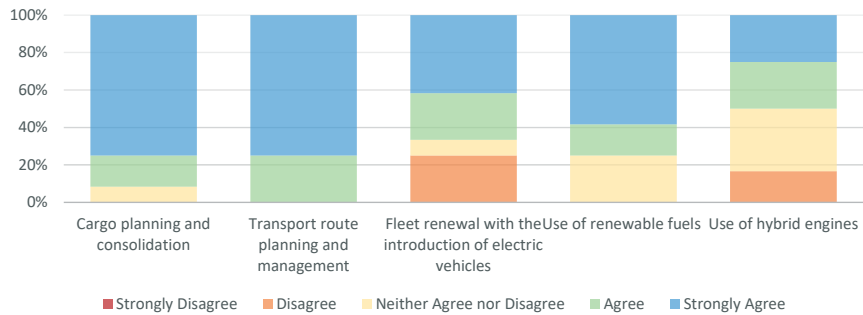


Figure 4 - Strategy towards the implementation of sustainable measures

With regard to the main drivers for the adoption of sustainable measures, the respondents are far from unanimous. Half of the respondents consider the requirements and targets set by management to be very important, while the other half consider this factor to be of little or no importance. A majority of the companies concerned see “contribution to reducing global warming as an important or very important A majority of the companies concerned see “contribution to reducing global warming” factor for adopting sustainable measures. These companies showed little sensitivity to “Demonstration of social responsibility”, Figure 5.

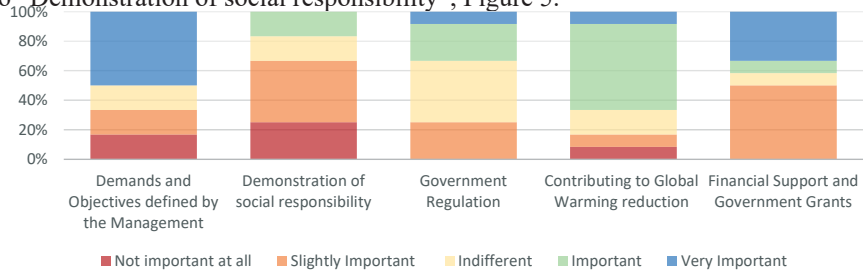


Figure 5 – Drivers for the adoption of sustainability measures

As the main difficulties in implementing these sustainability measures, most of the companies observed highlighted the “high initial financial costs”. In the opposite direction, these companies recognized that the “lack of knowledge and information of options” and the “lack of support from top management” are not impediments to the

implementation of sustainable measures, as can be seen in Figure 6.

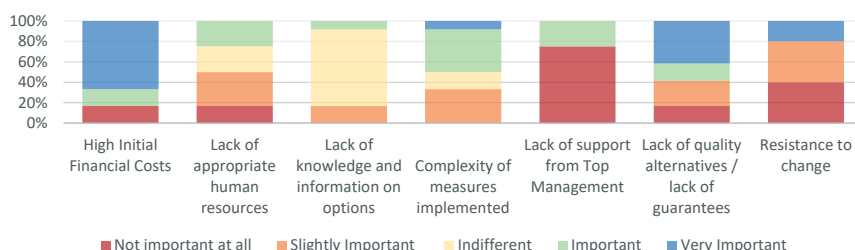


Figure 6 – Main obstacles in the adoption of sustainable measures

4.3. Positioning of the company in relation to available technological innovations

Regarding the importance and impact of the available technology options, companies were asked to rate from “strongly disagree” to “strongly agree” the following seven statements:

- 1- The company management knows and is up to date with the different technological options that contribute to the decarbonization of road transport and tries to apply them;
- 2- Environmental, social, and political factors play an important role when thinking of adopting innovative technologies;
- 3- The final result is the most important when adopting innovative technologies;
- 4- Improvements in the results obtained, by implementing technology are a major factor in determining investments in operations;
- 5- The company has invested or is considering investing in technological innovations as a way to reduce its carbon footprint;
- 6- The company has renewed or is planning to renew its vehicle fleet and has resorted to electric vehicles;
- 7- The company prepares and uses an operational plan for investment in transport technologies.

The answers are shown in Figure 7 and reveal some similarities between the companies. Statement 6 concerning fleet renewal and the use of electric vehicles appears as an exception in which answers show great dispersion of response. As to the question of which technologies are the most promising, the overwhelming majority mentioned natural gas and H2 cells. The option “Electric vehicles” was among the least chosen,

as was the option “solar mobility”. It should also be noted that any of the companies observed had made their last technological investment in transport in the last two years.

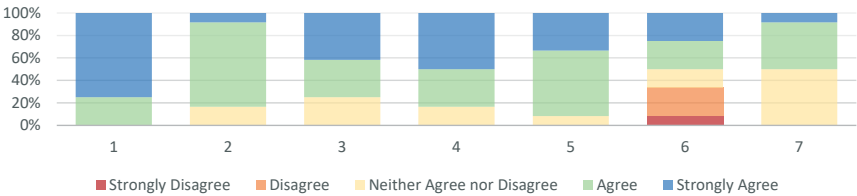


Figure 7- Degree of importance of the technological options available

Most of the surveyed companies invest between €100k and €200k in transport technology, all with annual turnover between €10M and €20M. Only one company was noteworthy in terms of its annual turnover (less than €10M) and the percentage of investment in technology was higher than that of the other respondent companies. The companies with the highest turnover did not respond to this question (Figure 8).

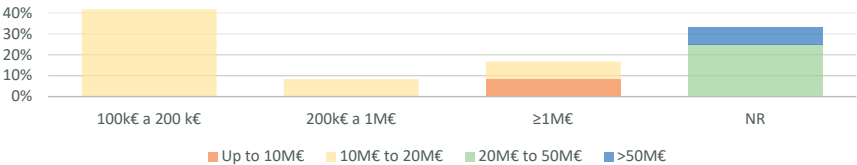


Figure 8- Average annual investment in technology according to turnover

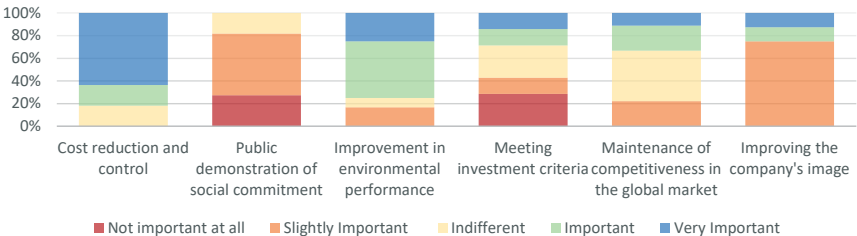


Figure 9 - Expected results of the investments

Finally, this group of companies was asked when they expect to achieve carbon neutrality with zero emissions. Two thirds stated that they intend to reach this goal by 2040. Figure 9 shows the expected results of the investments.

5. Conclusions

Based on the results obtained it was possible to conclude that large and medium-sized Portuguese freight transport companies are aware of and are investing in technological innovations with a view to sustainable transport. They understand the importance of including sustainable practices in the definition of their strategies, especially in route management and cargo planning and consolidation. The investment in technology is a unanimous strategy used to reduce greenhouse gas emissions and the reasons that lead companies to invest are the improvement in environmental performance, cost control and the consequent obtaining of competitive advantages. It was highlighted that hydrogen will play a key role in the energy transition because it has storage capacity and flexibility to be used not only in road transport but also in various sectors of the economy, being seen as the best solution for heavy vehicles. As obstacles, these companies highlight high initial financial costs and the complexity of the measures implemented. The small size of the sample collected prevented a deeper and wider study, however, the answers collected can be seen as a preliminary and indicative study in an area of crucial importance, both for large and medium-sized Portuguese haulage companies and for the design and monitoring of the targets to be achieved towards carbon neutrality in haulage companies in general.

Acknowledgements

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