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THE CARBON FOOTPRINT APPLIED TO THE TRANSPORT SECTOR AS AN INSTRUMENT OF TRANSITION TO THE CIRCULAR ECONOMY*

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Abstract

In order to reduce climate change, the Carbon Footprint Communication (CFP) was introduced: a parameter for estimating, monitoring, reporting and verifying greenhouse gas emissions caused by a product or a service. This indicator is used to determine the environmental impacts of emissions on climate change caused by humans. In the context of goods transport, road-only transport is more impactful than intermodal transport by sea and rail. The objective of this paper is to use the Carbon Footprint to quantify greenhouse gas emissions from goods transport. A case study is proposed which aims to propose alternatives for companies to be able to decarbonise the sector so as to achieve a reduction in emissions resulting in increased environmental and economic efficiency. "BROS. DI MARTINO LTD.", founded in Catania (IT) in eastern Sicily in 1969 and operating in the intermodal transport sector, was chosen because it boasts certifications such as ISO 9001 and ISO 14001.

Keywords: carbon dioxide, carbon footprint, decarbonisation, efficiency, inermodal transport

1. Introduction

Environmental labels are trademarks applied directly to a product or service and provide information on its overall environmental performance or on one or more specific environmental aspects (Stern et al., 1997).

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Ecological labelling is also highly diverse. According to the OECD, brands can be "public and compulsory", "public and voluntary", promoted by non-profit groups or private sectors or a mixture of these components, for example on the joint stimulus of NGOs and private sectors. The increasing number of eco-labels is due to the drive towards greater environmental sustainability of production and consumer systems. This push is based on different motivations (Matarazzo et al., 2018). Governments, aware that unsustainable behaviour poses an economic risk in the long run, impose mandatory standards for certification, as is the case with the EU's energy efficiency brand. In some cases, companies take voluntary measures to increase the sustainability of their businesses under the pressure of consumers or activist groups and generally want their commitment to become more sustainable to be recognized by an ecological quality brand (Porter and Van der Linder, 1997).

The main standards for the implementation of an Environmental Management System are two precisely: the ISO 14001 (2004) Standard; The European Parliament and the Council of European Parliament(s) are also not the only people who have been involved in the work. ISO 14001 (2004) is an international standard applicable to all organizations, specifying the requirements of an environmental management system.

EMAS is a Community Regulation that recognizes the achievement of excellence in environmental improvement; it integrated the EMAS registration procedures with those of ISO 14001. In this way, ISO 14001 certification can easily be a preliminary step (but obviously not mandatory) in the path to obtaining the EMAS registration.

The ISO 14020 (2002) set of standards provides for three types of ecological marks or environmental labels applied directly to a product or service that provide information about its overall environmental performance or one or more specific environmental aspects.

Ecological type I marks are voluntary ecological labels that are subject to external (or third-party) certification. They are incardinated into a system based on multiple criteria (different for each product category) that considers the entire product lifecycle. The criteria set threshold values, to be met in order to obtain the release of the trademark (EC Regulation 66, 2009)

The governing body for the allocation of the trademark may be public or private and is regulated by ISO 14024 (2018).

Type II Ecologic Labels are identified by ISO 14021 (2016). They refer to the life cycle of the materials or to a specific characteristic of the product. These are uncleared environmental self-declarations so verification is not mandatory (Law 231, 2018). Type II marks, on the other hand, consist of 'self-declarations' about the ecological characteristics of the product, and therefore the responsibility for its use lies with the company that uses it.

Type III marks are regulated by ISO/TR 14025 (2000).

They are represented by the Environmental Product Declaration (EPD), which reports information about the environmental impacts associated with the product's life cycle, calculated through an LCA system and is subject to an independent accredited body check. The EPD is suitable for products and services along the production chain and, referring to ISO standards, is internationally recognized.

Ecological labeling is an expanding sector. Currently, the Ecolabel Index (Ecolabel Index of Ecological Quality Brands) tracks more than 450 brands spread across 197 countries. An analysis by the Organisation for Economic Co-operation and Development in 2013 found that the number of brands increased roughly fivefold between 1988 and 2009 (Giampieri, 2013).

The introduction of environmental brands was a turning point for producers and consumers as a valuable tool for sustainable economic development (Musciagna, 2010). In fact, these patterns have developed to a significant extent in recent years and the increasing

numbers of their diffusion have helped to consolidate its role as a tool for the effective improvement of environmental performance by the economic system, in a perspective of sustainability.

The aim of the project is to report the emission of Gas Serra, in particular CO_2, CH_4 and N_2O during intermodal transport activities, considering that the transport sector has a major impact on total European emissions (Bonanno et al., 2018).

The impact of this sector on a country's GDP is called "Transport Intensity", this indicator increases from 1990 to 2005, with a regression in 2000, then and until 2012, there is a marked reduction then a further increase in 2013 and a further decrease until 2016.

A case study is proposed which, from the point of view of the circular economy, aims to propose alternatives for companies so that they can decarbonise the sector in order to achieve a reduction in emissions resulting in an increase in environmental and economic efficiency. The transport sector in Italy and in particular in Sicily, intermodal transport will be analyzed specifically and the application of the instrument will be carried out, comparing the results obtained in other companies in the sector and defining the benefits of the application of Carbon FootPrint in the company.

It is an environmental indicator that measures the impact of human activities on the global climate (Matarazzo et al., 2018); quantitatively expresses the effects produced on the climate by the so-called greenhouse gases generated by a person, an organization, an event or a product, be it a good or a service, using as a unit of measurement the ton of carbon dioxide equivalent (tCO_2e) that allows a comparison of the different types of gases to effect evening in relation to a unit of CO_2 (Luciani et al., 2011).

The calculation from carbon FootPrint (CFP) takes into account all the climate-altering gases of the Kyoto Protocol: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbon group (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF_6) (Wiedmann and Minx, 2008).

The CFP of the products includes the absorption and emission of climate-altering gases throughout the life of a product or service, from the extraction of raw materials and their processing, to their use and their final use, recycling or disposal. In each of these phases, greenhouse gas emissions can result from sources such as: the use of energy and fuels for transport, waste and refrigerant losses from refrigeration systems, while absorptions may result from atmospheric CO_2 fixation by plants or soil.

2. Case study

The company "F.lli Di Martino", national and international leader in the transport and logistics sector, thanks to its high professionalism, problem solving skills and experience, is among the top 100 transport companies in Italy for global turnover, number of employees, logistic platforms, branch warehouses, sales and service outlets located throughout the national territory and not (https://www.dimartinospa.it/).

The company originated in 1969, the result of a family business project undertaken by Angelo Di Martino, Captain of long course, Officer in the Merchant Navy, who, with the help of his brothers, founded a first transport company. With the passage of time this becomes a reference point for the entire Sicilian market.

The company "F.lli Di Martino spa" is a Global logistic provider that manages in a unitary way all the supply chain, from the origin to the destination. Its core businesses are transport, logistics, distribution and freight forwarding.

The company takes care of integrated logistics that is the entirety of activity of planning, coordination, management and control of the flows of goods and the flows informative to the aim to make to obtain the product that serves, in the quantities that serve,

in the place where it is needed, at the time of its use, with costs proportionate to the level of service requested, and in compliance with the quality parameters required by customers; It therefore deals with a set of services, both inside and outside the company for which it operates, and whether it carries out production or distributive business.

The logistics division of F.lli Di Martino offers an integrated offer of services from supply, transport and distribution, from storage to product traceability. With more than 2500 cargo units, the company offers LTL and FTL transport, groupage and distribution services at national and international level. In primary transport, vehicles are fully loaded. Full load transport is an advantageous way of minimizing the movement of goods that are loaded without interruption at the sender and unloaded at the recipient. Everything is carried out in compliance with current regulations and driving and parking times.

Secondary transport refers to the local distribution phase (out-bound) in urban areas or in limited geographical areas: from the central warehouse to free-service outlets; from peripheral depot or transit point to traditional points of sale; from transit point to distribution centers. In secondary transport the load can be partial or groupage and it means it might include several stops during a single journey.

The company is able to offer customers the best transport solutions combining in an optimal way, the intermodal road railway, short- sea (Ro-Ro) and, if needed, the air and oceanic freight. The integrated planning allows you to exploit the advantages of each mode of transport in relation to the needs of the customer. The intermodal transport (either through railway or short-sea shipping) allows to operate from and for any geographic area avoiding the breakage of cargo units bearing a great benefit both from the economic point of view and for the times of yield. The forwarding activity completes the range of services offered with that of ocean and air freight, which allow the management of intercontinental traffic of modern industry.

Business development and growth is the result of investments by the company in cutting-edge technologies and certification such as ISO 9001 (2015), ISO 14001 (2004) and Safety & Quality Assessment for Sustainability (SQAS) (https://www.sqas.org/) as well as investment in a modern fleet which includes 100% electric trucks for city, and LNG engines and Euro VI tractors for the long haul. The company is characterized by a high quality of the production process with a well-known and reliable brand throughout the European panorama.

3. Materials and methods

Today, public opinion is increasingly paying attention to the problem of climate change, and this has also led to the creation of new methods to provide information on the environmental impact of products and services. In this sense, the Carbon FootPrint (CFP) communication has recently been stated: it is an indicator for measurement, monitoring, reporting and verification greenhouse gas emissions at the level of a product or service and is defined as the total amount of greenhouse gases associated with it.

The identification of the carbon footprint and the implementation of carbon management are linked to benefits of a different nature, such as: qualifying as a potential provider for MNC and PA; access to tax breaks made available to only “environmentally deserving” companies; sales growth and consequent increase in economic revenue; increase in the company's green reputation (www.tecnosrl.it).

The CFP is defined as an environmental indicator that measures the impact of human activities on the global climate; quantitatively expresses the effects on the climate by the so-called greenhouse gases generated by a person, an organization, an event or a product, be it a good or a service. The calculation from carbon FootPrint takes into account all the climate-

altering gases of the Kyoto Protocol: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons group (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF_6).

The unit of measurement of the Carbon FootPrint is the ton of equivalent carbon dioxide (tCO_2e). Equivalent carbon dioxide (CO_2e) allows a comparison of the different types of evening-effect gases in relation to a unit of CO_2.

The Carbon FootPrint of products includes the absorption and emission of climate-altering gases throughout the life of a product or service, from the extraction of raw materials and their processing, to their use and their final use, recycling or disposal. In each of these phases, greenhouse gas emissions can result from sources such as: the use of energy and fuels for transport, waste and refrigerant losses from refrigeration systems, while absorptions can result from atmospheric CO_2 fixation by plants or soil.

The Carbon FootPrint is therefore a subset of the data from a Life Cycle Assessment (LCA) study. The LCA is an internationally standardised method, in particular by ISO 14040 (2006) and ISO 14044 (2006) for the assessment of environmental loads and resources consumed in stages; extraction of raw materials, production of goods, their use by end users, or provision of a service, recycling, energy recovery and final disposal.

While it is important that the concept of a 'carbon footprint' is all-encompassing and includes all possible causes that generate carbon emissions, it is equally important to clarify what it includes. Proper measurement of carbon footprints acquires importance and insecurity when it comes to compensating for carbon. It is obvious that a clear definition of scope and boundaries is essential when projects to reduce CO emissions are sponsored. When indirect emissions are taken into account, methodologies that avoid double emissions must be applied. In addition, a comprehensive product lifecycle assessment means that all stages of this lifecycle must be evaluated correctly (Wiedmann and Minx, 2008). The CFP helps in the management of emissions and in the evaluation of measures to reduce them. After qualifying emissions, it is possible to identify the largest sources of emissions and prioritise them in order to reduce their impact on the environment and increase their efficiency by reducing costs. Carbon footprint disclosure to third parties or disclosure to the public may be necessary in accordance with legislative requirements, either as part of corporate social responsibility or to improve brand image (Peters, 2010).

Carbon FootPrint reference documents are the first part of is ISO 14064:2006 (updated in 2012) and the GHG Protocol devised by the WRI and WBCSD GHG Protocol Initiative.

The aim is to develop safe detection and proofing systems that can be applied on a voluntary basis and potentially linkable within the Kyoto Protocol or other specific GHG programmes.

ISO 14064 is divided into three parts:

1. ISO 14064-1 (2019): Specifies the principles and requirements at the organization level for quantifying and accounting emissions.

2. ISO 14064-2 (2019): Outlines the principles and provides project-level guidance for quantifying, monitoring and reducing emissions.

3. ISO 14064-3 (2019): Defines requirements and principles for those interested in validating and controlling GHG assertions (Bastianoni et al., 2014).

A valid reference is ISO 14044, which establishes the procedure for developing a lifecycle analysis that encompasses all impact categories. Some countries have already moved in this direction; The United Kingdom (British Standard) has issued a rule to follow for the calculation of the carbon footprint that can be used for goods and services. This is the PAS 2050 (2011) rule, which is based on the aforementioned ISO 14040 and ISO 14044

standards, limited to greenhouse gas emission assessments due to the product under consideration.

This procedure is proposed by the Carbon Trust, a company that has the main purpose of facilitating the conversion of the market to an economy inspired by low-carbon energy sources.

The value obtained from the application of the Carbon Trust method can be turned into a label (Carbon Reduction Label) that shows how sustainable the product is in terms of greenhouse effect, thus allowing comparison of different products with the same function, while remaining the precautions already mentioned regarding the use of a single impact indicator.

At the international level, is that a specific standard on the carbon footprint of the product has been developed by the ISO 14067 (2018) (Carbon footprint of products). It is divided into two parts:

- ISO 14067-1: Quantification
- ISO 14067-2: Communications

In addition to the aforementioned Carbon Reduction Label of the Carbon Trust, a strong European spread is having the Climate Declaration, developed under the international Environdec system of the IEC consortium. It is essentially a communication extracted from an Environmental Product Declaration (EPD) and, therefore, regulated by ISO 14025: Labels and Environmental Statements - Type III Environmental Declarations, which allows reliable communication as it is based on an LCA study regulated by ISO 14040 and the verification of a third party (program operator).

4. Results and discussion

The choice to analyse emissions from a transport company stems from the significant weight of greenhouse gases produced by the sector both in Europe and around the world. Transport accounts for about one-quarter of emissions at European level, 74% of which is associated with road transport, while the remaining 26% is attributed to navigation and aviation. In particular, over the years, it has been shown that transporting goods by rubber is an important source of polluting emissions with an average contribution of 6% of the average total of the European Union.

Once analysis and selection of the most representative routes in the selected timeframe (a semester) is carried the Carbon Footprint tool can be applied to analyze the GHGs released during the intermodal transport for the selected routes.

In the calculation of the pollutants emitted, for simplicity, the three most present and most impactful will be considered: CO_2, N_2O and CH_4 calculated by using conversion tables consistent with IPCC (2007) standards.

The objective of the application of the Carbon Footprint to the company is to report the emissions released into the environment during the transport activity from Sicily to the east and west areas of the Mediterranean, in particular Greece and Spain in order to allow a reduction or compensation as provided by ISO 14067 (2018).

Routes to the most-served cities in both countries were analysed and the weighted average of kilometers traveled by road, ship and train was calculated. The frequency of the appearance of the routes in the second half of 2019, taken into account as a reliable reference sample, was used for the calculation of the weighted average. Below are the summary tables for both Greece and Spain with the percentages of the three means of transport and the tonnes per km (tKm) assuming that the load is constant and equal to 25t to make the calculations homogeneous and easily comparable (table 1 and table 2).

On the basis of the data collected, the Carbon Footprint was calculated on weighted total averages to highlight which pollutants and in what quantities are produced for the coverage of the two Mediterranean countries.

The data from the application of the tool is shown in Table 3.

Table 1. Summary data Greece

Country	***City served***	***Transport flow tKm***			***Percentages***			***Tot. Weighted average (KM)***		
		Road	***Ship***	***Train***	***Road***	***Ship***	***Train***	***Road***	***Ship***	***Train***
Greece	Eleusi	5017.5	16125	0	31%	69%	0%	5618	17538	0
	Corinto	3217.5	16125	0	20%	80%	0%			
	Apropyrgos	6655	25575	0	26%	74%	0%			
	Velestino	11453.3	22425	0	51%	49%	0%			
	Salonicco	11792	16125	0	73%	27%	0%			

Table 2. Summary data Spain

Country	***City served***	***Transport flow tKm***			***Percentages***			***Tot. Weighted average (KM)***		
		Road	***Ship***	***Train***	***Road***	***Ship***	***Train***	***Road***	***Ship***	***Train***
Spain	Linars Del Valles	3825	49575	0	8%	82%	0%	4544	51424	0
	San Pere de Ribes	1242.5	49575	0	2.5%	97.5%	0%			
	Antequera	15700	55375	0	28%	72%	0%			
	Beniparrel	1900	55375	0	3.5%	96.5%	0%			
	Fuentelapeña	14342	55375	0	26%	74%	0%			

Table 3. Amount of GHGs emissions for Greece and Spain

GHG	***Quantity issued (kg)***		***Impact indicator (Kg CO_2 Eq.)***	
	Greece	***Spain***	***Greece***	***Spain***
CO_2	1.0465	1.118877	$1.05E^3$	$1.18E^3$
CH_4	0.661	0.7	20.2	21.4
N_2O	0.0504	57.1	13.5	15.7

The choice to analyse emissions from a transport company stems from the significant weight of greenhouse gases produced by the sector both in Europe and around the world. Transport accounts for about one-quarter of emissions at European level, 74% of which is associated with road transport, while the remaining 26% is attributed to navigation and aviation. In particular, over the years, it has been shown that transporting goods by rubber is an important source of polluting emissions with an average contribution of 6% of the average total of the European Union.

Once you have carried out the analysis and a selection of the most representative routes in the reference semester, you can apply the Carbon Footprint tool to analyze the GHGs released during the intermodal transport activity.

In the calculation of the pollutants emitted, for simplicity, the three most present and most impactful will be considered: CO_2, N_2O and CH_4 calculated by using conversion tables consistent with IPCC (2007) standards.

The objective of the application of the Carbon Footprint to the company is to report the emissions released into the environment during the transport activity from Sicily to the

east and west areas of the Mediterranean, in particular Greece and Spain in order to allow a reduction or compensation as provided by ISO 14067 (2018).

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Table 4 can show that the heating potential, always expressed in gCO_2 equivalent, of carbon dioxide is significantly lower than that of CH_4 and that of nitrogen oxide.

It is found that, with the same amount emitted, CO_2 is less impactful than CH_4 and N_2O, but, as this study shows, the quantities differing from each other and this affects which gas is considered "most impactful".

Table 5 shows the data set used for each mode of transport, i.e. the processes considered in the calculation of emissions related to the use of each vehicle in relation to the type of carrier used by the company.

Table 4. Relevant GHG global warming potential. Conversion factors from IPCC (2007)

GHG	***Formula***	***GWP_{100} $[gCO_{2eq}/gGHG]$***
Carbon dioxide	CO_2	1
Methane	CH_4	25
Nitrous oxide	N_2O	298

Table 5. Description of the dataset used

Transport module	***Dataset description***
Transport, lorry, 16-32 t, EURO 6/RER	Included processes are the followings: operation of vehicle; production, maintenance and disposal of vehicles; construction and maintenance and disposal of road.
Transport, freight rail/IT	The following steps were considered: production, maintenance, operation, and disposal of the train; and construction and maintenance and disposal of railway tracks
Transport, freight ship/OCE	The module calls the modules addressing: operation of vessel; production of vessel; construction and land use of port; operation, maintenance and disposal of port.

Source: Prevention and control of emissions in intermodal transport: the importance of environmental protection

5. Concluding remarks

Given the growing importance of environmental issues and the reporting of emissions related to the entire life cycle of a product, it is crucial for companies to be proactive and anticipate the needs of the market as much as possible.

Through the study, it is possible for the company to adopt behaviors to reduce GHGs emissions with all the direct and indirect benefits of implementing the Carbon Footprint.

Reporting an exhaustive greenhouse gas inventory (GHGs) is a useful tool for an organization to raise awareness of its emissions.

Among the many advantages for the company are: facilitated approach in the development of strategies for controlling and reducing greenhouse gases; support in identifying processes with significant energy consumption; Starting point for developing

emission reduction programs also through compensation mechanisms and projects; support in identifying and managing GHGs obligations, benefits and risks; creating a validated information base as a benchmark to address entry into emissions trading markets; possible benefits, financing, facilitation and recognition of credits as a result of GHGs emission reductions "certified" by an Independent Body according to an international standard; instrument to validate CO_2 emission reductions, for example, with improvements in energy efficiency; budget of GHGs "certified" by an independent third party as a tool for communicating performance in terms of commitment and results in reducing greenhouse gases aimed at business partners, stakeholders, customers and authorities; ability to include verified budgets within environmental and sustainability budgets by improving the visibility and image of the organization.

Obtaining an ISO 14067 certification would represent an important competitive advantage for the company over its competitors and would be an indicator of foresight and proactivity as it is a voluntary rule that only came into force in 2018 and therefore not yet widespread, especially in the transport sector. There are many possibilities for reducing emissions, and in this the company being studied is favored by exploiting intermodality to better combine the different means of transport in order to find solutions with less impact.

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