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Reducing fuel consumption and carbon emissions through eco-drive training

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ABSTRACT

Freight transport is responsible for about 45% of total CO_2 emissions caused by mobility. To reduce its contribution without limiting the quantity of goods distributed, the technological improvement of vehicles and alternative fuels is only a partial solution. Indeed, it should be flanked by other integrative push- and pull-measures implemented at the policy level. Among them, eco-driving represents an option that covers strategic, tactical and operational decisions and provides suggestions to drivers, as well as real-time monitoring of their performance.

This paper brings some evidence to such assertion, first providing a summary of the literature assessing the impacts of eco-driving, and then highlighting the limited amount of studies regarding freight transport. The results of an eco-driving field trial conducted in the Chinese province of Jiangsu, whose data were gathered using a method based on real-time normalized indicators specifically developed by Deutsche Telekom AG, are then presented. 15 heavy-duty and 10 light commercial vehicles were monitored over a period of four months, and information was collected on more than 5200 trips, covering a total distance of 439,000 km. A comparison between the driving styles before and after the training revealed a reduction of unitary fuel consumption for heavy-duty vehicles (−5.5%), while no significant variations were visible for light commercial vehicles. The application of this research method also yielded useful information about braking, acceleration and standstill, which are normally not considered in these types of evaluations, but can be highly valuable to drivers who wish to modify their behaviour towards a more efficient style of driving.

1. Introduction

Greenhouse gases (GHGs) are a relevant indicator to evaluate transport sustainability (Black, 2010). In relative terms, transport counts for about 30% of total anthropogenic GHG emissions and its impact has increased by about 22% in comparison to 1990 levels, thus revealing a critical environmental issue that needs to be addressed urgently (EU, 2014). As it accounts for almost 45% of total energy that is consumed by transport (Sims et al., 2014), freight transport is significantly co-responsible for this rise.

Even if the adoption of alternative fuels can grant substantial benefits in terms of Tank-To-Wheel emissions (Nocera & Cavallaro, 2016a), the technological development of vehicles and alternative fuels is not enough to curb transport GHGs

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on its own. Specific policies to encourage a modal shift towards less polluting systems are necessary (Dray, Schäfer, & Ben-Akiva, 2012), as well as the definition of the correct role assigned to GHGs within urban mobility plans (Nocera & Cavallaro, 2014). Policy-makers are aware of this condition and, since the early 1990s, the EU has constantly increased its efforts to create a framework that also includes this aspect (DGET & Transport, 2006). The mid- and long-term continental goals are coherent with this approach, aiming at reducing GHG emissions by 40% before 2030 (EC, 2015) and by around 60% before 2050 (EC, 2011). At a global level, the agreement achieved at the Paris climate conference (UN, 2015) is also coherent with this necessity.

Stimulated by these international climate conventions, even private stakeholders (such as large logistics enterprises) have announced voluntary GHG emission reduction targets, which can be obtained through the adoption of specific transport measures. They are known as "push-" and "pull-" measures: the former are imposed on freight operators to obtain more equitable transport pricing, seeking to require transport users to bear a greater proportion of the real travel costs. They include financial instruments (e.g., taxes, charges and tolls) and technical and regulatory constraints (e.g., orders and bans). Pull-measures are implemented in order to minimize the impacts of private trucks and commercial vehicles by improving the attractiveness of existing less polluting alternatives.

The results deriving from the adoption of these measures are monitored through annual reports, which highlight the fuel costs registered for each vehicle. Indirectly, they can provide the approximate amount of GHG emitted and the negative impacts upon the global climate balance caused by logistics operations. This approach is part of the so-called macro-models, as it tries to explain how changes at a large temporal and spatial scale influence carbon production. However, these reports do not give evidence of any positive investment in low emission vehicles and of the positive impact of specific measures undertaken at the unitary level, which contribute to reduce the relative figures of GHG emitted per ton of load and mileage. The microeconomic evidence suggests the importance of considering the individual heterogeneity and decisions taken at the individual level for traffic and modal split outcomes (so-called "individual behaviour"). To this aim, highly accurate methodologies for detecting fuel available are still present, such as CAN Bus fuel detection technology, injection pipe sensors and sensors inside the tank measuring the filling level. Accurate telematics devices are able to combine these fuel measurements with the position detected from satellite receivers sending acquired telecommunication technology to an external server to enable on trip and post-trip fuel consumption monitoring. However, the overall operational costs of such systems are still too high and cheaper solutions have to be implemented to grant diffusion on a broader scale.

This paper assesses the potentialities of a specific transport measure (eco-driving) and its implications towards the reduction of fuel consumption and carbon dioxide (CO_2) emissions from freight transport. CO_2 is a valid indicator to assess global warming caused by freight (McKinnon & Piecyk, 2009), since it counts for 93–95% of total GHG emissions from freight transport. Results are provided by integrating a micro-modelling approach to the annual reports previously recalled. Our intention is to assess the reliability of this model in providing real-time indications about driving styles and consequences on fuel consumption. At the same time, the efficiency of eco-driving as a measure to reduce CO_2 emissions caused by freight transport is analysed. The paper is structured as follows: Section 2 explains the nature of eco-driving, including a literary review of its effects, the phase of implementation and the expected fuel and carbon potentiality. Section 3 describes the methodology that we adopt to measure the expected reduction of fuel consumption and to help drivers know how to improve their driving efficiency. This methodology is tested on a case study in China and discussed in comparison with results found in the literature (Section 4). Some final remarks and policy implications (Section 5) conclude this contribution.

2. Eco-driving, fuel consumption and CO_2 emissions

Eco-driving is a generic term used to describe an energy-efficient use of vehicles that is based on the decisions and behaviours adopted by drivers. Behind this concept, it is assumed that while the performance of cars has improved rapidly due to technological developments and the introduction of alternative fuels, drivers have neither modified nor adapted their driving behaviours. If an adequate education about strategic, tactical and operational decisions is provided to drivers, eco-driving can contribute to limit overall fuel consumption and CO_2 emissions (Sivak & Schoettle, 2012). More in detail, specific measures can be adopted in the pre-trip, on-trip and post-trip phases (Wengraf, 2012). Regarding pre-trip activities, eco-drive manuals suggest performing maintenance checks of the vehicle, gauging the tyre pressure and assessing if there is any unnecessary vehicle weight, and making a detailed plan of the trip that seeks to find short-distance alternatives. During the trip, some practical recommendations may be useful, including a limited use of air conditioning, the avoidance of unnecessary engine idling, sharp acceleration and heavy braking, changing up gear as soon as possible and anticipating traffic behaviour. Finally, post-trip activities include reviewing data about the trip, which can be made by employing specific apps or satnavs. Eco-driving does not imply the use of all these recommendations. However, some of them can be used in a combined form to obtain multiple benefits, including private financial aspects (the saving of fuel and money), safety (less accidents), environment (reduction of global emissions, local air pollutants and noise), and society (more responsible driving stile and reduction of traffic congestion).

In the most commonly used form of eco-driving measures, drivers are given advice in classes or training sessions. The organizers measure differences in fuel consumption and CO_2 emissions before and after the training, thus determining the efficiency of the lessons. The results are then communicated to drivers using two main forms of feedback (Fig. 1). The real-time indicator relates the driving style of the drivers to other external conditions, such as type of road or congestion