Chapter 2
AI for Green Logistics and Decarbonized Transport Performance of Transport Organizations in Morocco

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ABSTRACT

This study addresses the climate emergency by assessing the environmental performance of 270 Moroccan transport organizations (2019–2023) using four machine learning algorithms: Random Forest, XGBoost, SVM, and PLS. Among them, XGBoost achieved the best results with an R^2 of 0.88 and F1-score of 0.83 in predicting fuel consumption and classifying environmental performance. The analysis identified route optimization and adoption of low-emission vehicles as key factors influencing environmental outcomes. The study also highlights differences in these factors' effectiveness across organization types (public vs. private) and sizes (SMEs vs. large firms). Ultimately, the research proposes a robust, data-driven framework to enhance environmental performance and guide public policies and managerial strategies towards greener logistics and decarbonized transport in Morocco.

INTRODUCTION

The world is currently experiencing an unprecedented climate emergency involving rising average temperatures, increased occurrence of extreme weather events, and global recognition that GHG emissions must drastically be curtailed (IPCC, 2006).

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In this situation, the internationalization of firms, particularly SMEs, represents both value-added strategic threat and growth mechanism (OECD, 2022). However, many Moroccan SMEs see internationalization as more uncertainty, high logistic costs, and lack of technical support (Chamchati et al., 2021). The paradox can hold also to the transport sector, an industry with all the typical qualities which generates a considerable amount of GHG emissions, as organizations are being asked to change to sustainable practices (IEA., 2022).

National data suggests that the transport sector would contribute around 40% of total GHG emissions by 2022 with an emphasis on road transport (Climate Change Department, 2024). This indicates the key role that transport organizations must play in developing a viable path to sustainability. Transport organizations will include the Office National des Chemins de Fer, (ONCF), road freight and passenger transport companies, operators of ports such as Tanger Med and Casablanca, and airports such as Mohammed V Casablanca, and Marrakech-Ménara. Each of the above mentioned organizations are in a constant struggle to meet the expectations of their economic missions while adhering to demanded environmental requirements. Transport organizations particularly face challenges; the aging of their fleets, the lack of adapted infrastructures (electric charging stations, natural gas refuelling stations), and the burden of the initial costs associated with the ecological transition, as they very often operate in a economically constrained existence (AMEE, 2023; World Bank Group, 2022).

Furthermore, traditional approaches to assessment of the environment are showing their limitations due to the increasing complexity of transport systems. Traditional environmental audits using a finite number of static indicators and often based on descriptive analysis (averages, standard deviations) lack the ability to take into account the multifactorial and temporal dynamics contained within the environment (Patella et al. 2021). In addition, traditional assessments are incapable of effectively depicting the immense heterogeneous data space resulting from transport operations (e.g. telematics, GPS location, predictive maintenance, real-time consumption patterns) and are unable to model the complex non-linear relationships in the data space (Azad et al., 2024).

Given these constraints, machine learning (ML) is emerging as a new way to attain relevance that may overcome the shortcomings of traditional ways. ML can reveal patterns in data that were previously hidden, capture complex relationships, and provide robust predictions to provide strategic insight (Goodfellow et al., 2016 ; Tabachnick & Fidell, 2013). Algorithms like Random Forests (RF), XGBoost, Support Vector Machines (SVM) or Partial Least Squares (PLS) regression have shown their strength in predicting complex phenomena in many fields including finance, health or energy (Chen, & Guestrin, 2016 ; Breiman, 2001). However, while these algorithms have been applied extensively to many other areas, they are only