Better understanding the impacts of regulatory environmental policies on inventory and fleet replacement

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Abstract

Freight transport is a recognized generator of disproportionate negative externalities: pollutant and greenhouse gas emissions, traffic congestion, noise, road safety issues, and others. The massive emissions due to transportation are especially problematic; studies alert that continuing with the current behavior will increase emissions by approximately 30% compared to 1990 levels in the next thirty years, generating significant consequences for the climate and the lives at least in U.S. (U.S. Department of Energy & Office of Scientific and Technical Information, 2013). According to the world's leading scientists, we must radically shift our carbon-based economy by 2030 (United Nations, 2015). The world must reduce emissions by 45% by 2030 and reach net zero emissions by 2050 to stop warming at 1.5C. Otherwise, conditions will significantly worsen on earth for a significant part of the population. To mitigate these impacts, transportation and environmental agencies in the U.S. have developed several guidelines, plans, and regulations. These include fuel taxes to discourage combustion engine vehicles, strict fuel efficiency standards, financial incentives to replace old truck fleets, and others measures. More recently, states in the U.S. have released plans to encourage the use of zero and near-zero emission vehicles. If effective, these initiatives will generate much needed benefits for sustainability. However, considering the cost and technical features of this vehicles the immediate impacts to businesses and fleets are not necessarily understood. To fill this gap, this research aims to evaluate the direct economic impacts of environmental policies on logistics practices (i.e., inventory replenishment and fleet purchase decisions). The study considers two policies seeking to improve the environmental efficiency of transport operations. The first limits the amount of transportation operation emissions, while the second demand a fleet mix to include zero and near-zero emission vehicles. To analyze these policies, the researchers propose the use of an extension of the Joint Replenishment Problem (JRP). This extension deals with two objectives; minimizing cost and minimizing emissions due to transport operation when replenishing inventory, while faces a stochastic demand and limited capacities. To solve the mathematical problem the authors propose a multi-step heuristic based on evolutionary and greedy search algorithms. From the companies' perspective, this model is a useful tool to determine both inventory policies and fleet composition in a cost-efficient way when the level of emissions produced by vehicles is limited by regulatory policies. On the other hand, from the transportation planner's perspective, this model allows to determinate more accurate the financial need of the companies when facing regulatory policies, then the planners could design more adequate programs to support the replacement of internal combustion vehicles. Preliminary results evidence the trade-off between capital investments in zero-emission vehicles and logistics costs to abide by the potential requirements. The output of empirical cases shows that the ratio cost/emission reduction is not linear, meaning that investing a large amount of money in fleet replacement does not necessarily reduce effectively

emissions. By better understanding the companies' inventory replenishment dynamics, it could be designed more efficient fleet replacement policies.

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Electric Vehicles, JRP, Sustainability, Freight transportation, Optimization.

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Biographies

Miguel Jaller is an Associate Professor in the Department of Civil and Environmental Engineering at the University of California, Davis, and Co-Director of the Sustainable Freight Research Centre at the Institute of Transportation Studies (ITS) Davis. He has strong theoretical foundations and practical experience in industrial and transportation engineering and management. He received his B.Sc. and M.Sc. in Industrial Engineering from Universidad del Norte, Colombia, and his M.E. in Transportation Engineering, M.Sc. in Applied Mathematics, and Ph.D. in Transportation Engineering from Rensselaer Polytechnic Institute. His multi-disciplinary research interests are in the areas of freight transportation, sustainable transportation systems, disaster response logistics, supply chain management, and operations research. His work concentrates on analyzing the societal and private impacts of transport and logistics operations, technology and policy; and developing decision making tools to achieve a sustainable transportation system.

Carlos Otero-Palencia is a second year Ph.D. student in the Civil and Environment Engineering Department at UC Davis. He has BAs and master’s degree in Industrial Engineering from Universidad del Norte, Barranquilla-Colombia, where Carlos was also an assistant professor. He has practical experience in industrial engineering projects related to supply chain optimization and transportation. His research focuses on inventory and supply chain management, collaboration in logistics, supply chain finances, freight transportation, green-friendly technologies in transportation, and optimization. He current working on logistic strategies/policies to reduce both logistic cost and carbon emissions in the supply chain operation.