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Direct impacts of off-hour deliveries on urban freight emissions

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ABSTRACT

The most significant negative environmental impacts of urban trucking result largely from travel in congested traffic. To illustrate the potential of innovative solutions to this problem, this paper presents new research on the emission reductions associated with *off-hour* freight deliveries (OHD). The paper uses fine-level GPS data of delivery operations during regular-hours (6 AM to 7 PM), and off-hours (7 PM to 6 AM), to quantify emissions in three major cities in the Americas. Using second-by-second emissions modeling, the paper compares emissions under both delivery schedules for: reactive organic gases, total organic gases, carbon monoxide, carbon dioxide, oxides of nitrogen, and particulate matter. The results show that the magnitude of the emission reductions depends on the extent of the change of delivery time. In the case of the "Full" OHD programs of New York City and São Paulo—where the deliveries were made during the late night and early morning periods (7 PM to 6 AM)—the emission reductions are in the range of 45–67%. In the case of the "Partial" OHD used in Bogotá (where OHD took place between 6 PM and 10 PM), the reductions were about 13%. The emission reductions per kilometer are used to estimate the total reductions for the cities studied, and for all metropolitan areas in the world with more than two million residents. The results indicate the considerable potential of OHD as an effective—business friendly—sustainability tool to improve the environmental performance of urban deliveries. The chief implication is that public policy should foster off-hour deliveries, and all forms of Freight Demand Management, where practicable.

1. Introduction

The threat of climate change and the health toll caused by air pollution have created enormous pressure to reduce greenhouse gases (GHGs) and local pollutants in urban environments. As one of the largest sources of such emissions, the transportation sector must play a leading role in finding technological, operational, and behavioral solutions to improve urban

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sustainability. Policy makers have recognized this reality, and have enacted numerous initiatives to reduce the environmental pollution produced by mobile sources.

Understandably, a great deal of emphasis has been placed on the use of environmental regulations that seek to cap, and ultimately lower, the amount of pollutants emitted by the various sectors of the economy. In mobile sources, this has taken the form of increasingly strict vehicle emission or efficiency standards for new vehicles. Arguably, these stricter standards have improved environmental conditions with tangible health benefits. However, in the case of freight vehicles—the main subject of this paper—the tightening of emission standards has generally been resisted by the trucking industry. Private-sector carriers argue that the incremental costs associated with the newer standards produce undue financial pressure on an industry characterized by chronic over-supply; an industry where a competitive market with marginal cost pricing is typically the norm. In such markets, additional investments in fixed assets like vehicles cannot be recovered by the prevailing rates. As a result of its position, the trucking industry is generally perceived as an opponent of sustainability and environmental improvements. The authors believe that despite its position on emission standards, which is explainable within the realities of the market, the trucking industry can become full partners in the quest for sustainability. The key to progress is to design appropriate win-win opportunities for such collaborations to emerge.

The field of Freight Demand Management (FDM) provides such opportunities. FDM seeks to induce behavioral changes on the *generators* of freight demand—the "receivers" of the cargo—to increase the sustainability of the freight traffic that is created. The importance of differentiating freight demand and freight traffic is central to FDM. The former is related to the need of commercial establishments and households to consume goods; the latter represents the flow of freight vehicles needed to transport those goods. The chief implication is that freight traffic is only a physical expression of the demand—albeit, one that produces significant amounts of negative externalities. Some of these effects are the responsibility of carriers, while others are the responsibility of the receivers. For example, the emissions emitted by a poorly maintained truck are the clear responsibility of its owner. In contrast, the congestion produced by a truck making deliveries during congested traffic hours is ultimately the responsibility of the receiver, who typically dictates when deliveries must be made.

The role played by the interactions among shippers, carriers, and receivers in the generation of the various externalities produced is not widely understood. For this reason, numerous programs aimed at increasing the sustainability of freight activity focus on its most visible expression, the vehicles, and implicitly assume (such as in road pricing) that carriers decide with complete freedom when and how they travel. Such programs ignore the constraints placed on carriers by the shippers and receivers. Such programs also rarely succeed, because receivers determine how and when they wish to receive deliveries; carriers generally cannot induce shippers and receivers to change their behavior. In contrast, FDM recognizes the pivotal role played by the receivers, and accordingly seeks to change the receivers' demand in order to indirectly change the behavior of shippers and carriers (Holguín-Veras and Sánchez-Díaz, 2016). FDM seeks to induce changes in the timing, number, destination, and/or the mode used to make deliveries to reduce the externalities produced by the associated freight traffic. Off-Hour Deliveries (OHD), the FDM program studied in the paper, induces receivers to change the time of deliveries.

A number of potentially transformative FDM programs could be considered (Holguín-Veras and Sánchez-Díaz, 2016), including, in addition to OHD: (1) Staggered Delivery Programs, where the receiver is incentivized to spread out deliveries during the work hours, helping to lower peak-hour freight traffic, thus reducing emissions during the peak hours; (2) Receiver-Led Consolidation Programs, which reduce the number of deliveries that arrive at a given location, lowering freight peak-traffic and the congestion it generates; and (3) Destination Change Programs where deliveries are sent, not directly to the receivers, but to another location where they are consolidated and sent to the receivers using environmentally-friendly vehicles. These strategies were successfully used during the London Summer Olympics, to ensure a timely flow of the supplies required to satisfy the needs of the local economy, the millions of visitors to the games, and the local residents, at the same time that large portions of the primary road network had been allocated to the exclusive use of the Olympic Games (COE-SUFS, 2013b; Browne et al., 2014). By estimating the emission reductions from OHD, the paper provides insight into the potential impacts of FDM as a central component of a holistic strategy to foster the sustainability of freight activity.

The role that receivers could play in a sustainability strategy was recognized as the result of a large body of research that used game theory and other forms of behavioral research. The focus of the research was the interconnections between the constituent agents of an elementary production-consumption link: the shipper, the carrier, and the receiver (Holguín-Veras et al., 2007; Holguín-Veras, 2008; Holguín-Veras et al., 2008; Holguín-Veras, 2011). The analyses of these relations have conclusively established that in a competitive market, receivers have significant influence over when, where, and how deliveries are made. The reason is simple: shippers and carriers have to be responsive to the needs and desires of receivers. Since receivers are the customers, shippers and carriers that do not deliver the supplies in the manner desired by the receiver run the risk of being replaced by more accommodating competitors. The chief role played by receivers implies that public policies that induce beneficial behavioral changes in receivers—particularly those located in congested areas—are likely to lead to changes in the behavior of shippers and carriers; systemic changes that will reduce freight externalities. The chief findings of the behavioral research conducted can be summarized as follows: (1) receivers are the key decision-makers regarding time-of-delivery because, generally speaking, carriers do what receivers say; (2) carriers do not need incentives to participate in OHD, because the cost savings from OHD are more than enough incentive; (3) receivers do need incentives to accept OHD, otherwise they would not become involved because of the perceived risk and/or business inertia; and (4) once a sufficient number of receivers agree to OHD, and carriers can justify at least one off-hours delivery route, a shift to OHD takes place.

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