

# Necessary conditions for off-hour deliveries and the effectiveness of urban freight road pricing and alternative financial policies in competitive markets

José Holguín-Veras \*

*Department of Civil and Environmental Engineering, Rensselaer Polytechnic Institute, JEC 4030, 110 8th Street, Troy, NY 12180, USA*

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## Abstract

This paper discusses the economic conditions needed to move urban freight delivery traffic to the off-hours, and the effectiveness of alternative policies to foster such move in competitive markets. Such policies seem to be needed because the empirical evidence indicates that in urban freight competitive markets freight road pricing may not be the most effective way to move truck traffic out of the congested hours. This is because: the decision about delivery time is jointly made between the carrier and the receiver; the carriers have great difficulties passing toll costs to receivers; and, in the few cases where toll costs could be passed, the price signal reaching receivers is of no consequence compared to receivers' incremental costs of off-hour deliveries. Three different policies are considered: freight road pricing combined with financial incentives to receivers willing to accept off-hour deliveries, freight road pricing, and laissez faire conditions (neither freight road pricing, nor financial incentives). The paper uses an economic formulation to estimate the impact a policy would have on the agents' profits, which provides insight into how the agents would react, and leads to a set of necessary conditions for off-hour deliveries to be feasible. Two cases of industry structure are considered: independent operations (carrier and receivers are separate companies) and integrated operations (carrier and receiver part of the same company). The particular case of large traffic generators, with central delivery stations is also discussed.

The analyses of integrated carrier–receiver operations indicate that, because of the centralized decision making process, they could transfer all or none of the delivery operations to the off-hours. This enables them to take full advantage of the carrier savings during the off-hours, that are at a maximum when all deliveries in a tour are transferred to the off-hours. The analyses of independent carrier–receiver operations conclude that the decision about delivery time is the outcome of the interaction between carriers and receivers as part of the Battle of the Sexes game, where the receivers play the dominant role. The paper highlights that, because of the competitive nature of the urban delivery industry, rates tend to be set at marginal costs. This, in turn, prevents carriers from transferring toll surcharges to customers because the tolls are, generally, a fixed cost that does not enter into the marginal cost. As a result, receivers in competitive markets are not likely to receive any price signal; that are only possible in the industry segments in which the carriers enjoy oligopoly power. Equally significant is that, even in those cases, where the carrier could pass toll surcharges to their customers (9% in New York City), the price signal is of no consequence when compared to the incremental costs to receivers associated with off-hour deliveries. To overcome this, the paper suggests the use of tax incentives to receivers willing to accept off-hour deliveries, combined with freight road pricing as a revenue generation mechanism. The analyses of large traffic generators reveal that these facilities represent

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\* Tel.: +1 518 276 6221; fax: +1 518 276 4833.

E-mail address: [jhv@rpi.edu](mailto:jhv@rpi.edu)

an ideal target for off-hour delivery policies because they could handle off-hour deliveries at a minimal incremental cost, which is a consequence of the scale economies associated with handling deliveries for multiple businesses.

The paper highlights that, because of marginal cost pricing, toll schemes based on distance and/or time spent in a tolled region will enable the carriers to pass toll costs to the receivers, as the tolls would enter in the marginal costs and therefore freight rates. This, however, would not resolve the issue pertaining to the insignificance of the price signal reaching receivers relative to the incremental costs associated to moving to the off-hours.

The analyses of the necessary conditions for the policies considered in the paper indicate that the most potent stimulus is provided by freight road pricing in combination with financial incentives to receivers. The paper concludes that neither freight road pricing by itself, nor *laissez faire*, are likely to achieve the goal of inducing a significant switch of truck traffic to the off-hours. © 2007 Elsevier Ltd. All rights reserved.

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## 1. Introduction

The idea of reducing urban congestion by moving freight deliveries to the off-hours, i.e., outside regular business hours, is older than what most people think. The oldest implementation on record is due to Julius Caesar, who promulgated an edict banning commercial deliveries during the daytime (Dessau, 1892). This edict is part of what Dessau calls the “*Lex Iuliana Municipalis*” on the basis of references in Cicero’s correspondence to a comprehensive law of Caesar’s which dealt with municipal affairs. As a result of Julius Caesar’s edict, urban deliveries were allowed only during the evening hours. The law is also referred to as “*Tabula Heracleensis*,” because the text was found in 1732 in Heraclea, Southern Italy, inscribed on a bronze tablet dating from the year 45 BC. Some scholars suggest that the street regulations were based on the laws of Greek cities (Roth and Roth, 2000). This suggests the intriguing proposition that traffic congestion required legislation not only in Rome but even in earlier times in Greece. It is very telling that Julius Caesar’s edict generated community complaints about the noise generated during evening hours, an issue that still remains today as an obstacle for off-hour deliveries; and is considered to be the key reason why some municipalities want to curtail off-hour deliveries (Browne et al., 2006).

However, the notion of using pricing as a tool to induce a socially optimal level of traffic is indeed more recent, dating back to the 1960s when a flurry of important publications took place (Walters, 1961; Nelson, 1962; Vickrey, 1963, 1969; Johnson, 1964; Beckman, 1965) – notwithstanding Pigou’s mention of the concept (Pigou, 1920). Since then, road pricing has elicited great interest because of its potential as a transportation demand management, and revenue generation tool. Following successful implementations in Singapore, California, and London, there is consensus among academicians about the social benefits brought about by road pricing of passenger car traffic, a conclusion that has been corroborated by real-life implementations and analytical studies (Sullivan and Harake, 1998; Brownstone et al., 2003; Sullivan, 2003; Brownstone and Small, 2005; De Palma et al., 2005; Olszewski and Xie, 2005). There is no such consensus, however, about the impacts and effectiveness of freight road pricing (FRP). This is because of the lack of empirical studies that provide evidence on observed behavioral impacts; and of a general behavioral theory that could explain the complex interactions underlying freight decision making.

This paper discusses the economic conditions needed to move urban freight delivery traffic to the off-hours, and the effectiveness of alternative policies to foster such move in competitive markets. Such policies seem to be needed because the empirical evidence indicates that freight road pricing may not be the most effective way to move truck traffic out of the congested hours (Holguín-Veras et al., 2006b). As discussed later in the paper, this is because: the decision about delivery time is jointly made between the carrier and the receiver; the carriers have great difficulties passing toll costs to receivers; and, in the few cases where toll costs could be passed, the price signal reaching receivers is of no consequence compared to receivers’ incremental costs of off-hour deliveries. In this context, a weak or completely absent price signal reaching the receivers deprive them of the only incentive to switch operations to the off-hours. Three different policies are considered: freight road pricing combined with financial incentives to receivers willing to accept off-hour deliveries, freight road pricing, and *laissez faire* conditions (neither freight road pricing, nor financial incentives). The paper uses

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