URBAN DELIVERY INDUSTRY RESPONSE TO CORDON PRICING, TIME-DISTANCE PRICING, AND CARRIER-RECEIVER POLICIES

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ABSTRACT

The paper develops a set of analytical formulations to study the behavior of the urban delivery industry in response to demand management policies. The analytical formulations consider a base case, and a mixed operation with both regular hour and off-hour deliveries; two pricing schemes: cordon time of day, and time-distance pricing; two types of operations: single tour, and multi-tour carriers; and three different scenarios in terms of carrier profitability. The chief conclusion is that cordon time of day pricing is of limited effectiveness for freight demand management because: (1) in a competitive market the cordon toll cannot be transferred to the receivers; and (2) the structure of the cost function does not provide any incentive to the carrier to switch to the off-hours. The analyses of time-distance pricing clearly indicate that, though its tolls could be transferred to receivers, the magnitude of the expected toll transfers under real life conditions are too small to have any meaningful impact on receivers choice of delivery times. In essence, the key policy implication is that in order to change the joint behavior of carrier and receivers, financial incentives should be provided to receivers in exchange for their commitment to do off-hour deliveries.

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INTRODUCTION

In spite of the voluminous body of research on pricing, only a handful of publications deal with the important area of freight road pricing. The literature review revealed only one publication (Holguín-Veras et al., 2006) focusing on the observed behavioral responses of urban carriers to cordon time-of-day pricing. The analyses of the behavioral data collected produced findings that challenge long-held assumptions. The data showed that: (1) the ability of carriers to unilaterally change delivery times is quite limited as it necessitates the concurrence of the receivers (which tend to prefer deliveries during the regular hours as they could take advantage of the staff at hand, as opposed to off-hour deliveries that may require extra staff, security, lighting, and other costs); and, (2) cordon tolls are not likely to be effective in inducing a switch to the off-hours, as most segments of the urban freight industry cannot pass toll costs to their customers depriving them of the price signal needed to effect a change. Further analyses (Holguín-Veras, 2008) concluded that the difficulties that carriers have to pass cordon time-of-day tolls to their customers reflect a highly competitive market with delivery rates equal to marginal costs. Since the cordon toll is a fixed cost—as it does not depend on the unit of output—it does not enter in the rates. The empirical data confirmed that only the market segments with market power (i.e., carriers of stone/concrete, wood/lumber, food, electronics, and beverages) could pass toll costs in a meaningful way (Holguín-Veras, 2008). The key insight is that, since the price signal only reaches the receivers in those cases where the carrier has market power (and in a diluted fashion because they allocate the toll costs among the multiple receivers in the tour), carrier centered pricing policies are not as effective as they should be because receivers have no incentive to change behavior. Since the consent of the receivers is needed for the carriers to change behavior, it follows that a new policy paradigm is needed. These new policies specifically target the receivers of the cargoes as well as the carriers, and are referred to as "carrier-receiver" policies. The goal here is to combine elements of carrier centered policies, e.g., freight road pricing, with receiver centered policies.

A number of carrier-receiver policies were designed and evaluated in a series of papers that: discussed constraints to implementation of off-hour deliveries (Holguín-Veras, 2006); analyzed the potential of the restaurant sector as a target for off-hour delivery programs (Holguín-Veras et

al., 2006); provided a framework for analyses of carrier-receiver interactions, and discussed the behavioral models estimated with stated preference data collected from receivers and carriers (Holguín-Veras et al., 2007; 2007). These behavioral models clearly showed that: (1) receivers would be willing to switch to the off-hours in exchange for financial incentives; (2) all carriers are sensitive to requests from receivers; and, (3) only a handful of industry segments are sensitive to tolls (i.e., carriers of petroleum/coal, wood/lumber, food products, and textiles/clothing). The analyses clearly indicate that this type of policy will be supported by the carriers as delivering in the off-hours, in equality of conditions, is about 30% cheaper than delivering during the congested hours of the day (Holguín-Veras, 2006).

Taken together, the research on carrier-receiver policies has provided insight into their effectiveness, and the limitations of freight road pricing. However, in spite of the significant progress made towards understanding carrier-receiver interactions, and how they shape their joint response to pricing, there are still major knowledge gaps. One of the most important ones is the lack of analytical formulations to assess the effectiveness of various combinations of financial incentives to receivers, and toll surcharges targeting carriers. The techniques that have been used have some limitations. Using a sequence of discrete choice models, which was the first approach used (Holguín-Veras et al., 2007; 2008), cannot take important details (e.g., routing patterns, configuration of service areas) into account. This translates into a rather coarse way to estimate the joint response. Currently, the only way to study such operational aspects is with the use of micro-simulation techniques that replicate the behavior of individual receivers and carriers (Silas and Holguín-Veras, 2008). Although able to model the observed behavior in a fine level of detail, such simulations require a significant amount of data and calibration effort, which hampers their implementation. Having access to closed form models could simplify the analysis process significantly. Among other things, such formulations could provide insight into how effective cordon time-of-day pricing, time-distance pricing, and comprehensive carrier-receiver policies are for a variety of operational conditions.

The paper builds on the author's previous work (Holguín-Veras, 2008) that outlined the necessary conditions for such policies to succeed in inducing a shift of truck traffic to the off-hours. The main focus is on the development of analytical formulations to assess the impact of policies targeting receivers and carriers. The formulations are developed with the assistance of

conceptualizations of the behavior of carriers and receivers. The resulting models are then used in numerical experiments to examine the impacts of off-hour deliveries on the industry.

The paper considers the case of a single carrier that is delivering goods to a set of receivers during the regular hours (base case conditions) from a location outside of the tolled area, i.e., the most typical case. It is also assumed that as a consequence of carrier-receiver policies, some or all receivers decide to receive goods during the off-hours, while others prefer receiving regular hour deliveries, and that no customers are lost because of the partition. Under these circumstances, the carrier would need to make two tours (i.e., regular and off-hours), and must to decide whether or not to conduct off-hour deliveries on the basis of the financial impacts associated with the resulting mixed operation. The formulations discussed in the paper are intended to help gain insight into the joint carrier-receiver response. (Although it is certainly possible that some carriers could do both regular and off-hour deliveries in the same tour by proper timing of the deliveries, or by waiting inside the tolled area, these cases are not considered here for the sake of brevity. This should be the subject of future research.)

The paper considers the case of independent carrier-receiver operations, and two different sub-cases of operational patterns (i.e., single, and multi-tour carriers). Independent carrier-receiver operations refer to the situation in which carrier and receiver are separate companies, each trying to maximize profits; as opposed to integrated carrier-receiver operations where both carrier and receiver belong to the same parent company. Since the latter case was sufficiently discussed in a previous publication (Holguín-Veras, 2008), there is no need to repeat the discussion here.

Two different toll schemes are considered. The first one is a cordon time of day system with a toll surcharge for travel during the regular hours, which is one of the most common road pricing schemes. Other schemes, e.g., the carrier only pays the toll surcharge once a day, could be accommodated by suitable adjustments to the toll surcharge. The second one is a time-distance tolling regime with tolls that are a function of time spent and distance traveled in the tolled area.

The analytical formulations provide insight into the effectiveness of pricing schemes as a freight demand management tool. Two results stand out. The first one is that cordon time-of-day pricing is of limited use for freight demand management purposes. This is because of: (1) in competitive markets carriers have great difficulties passing toll costs to receivers; and (2) the cordon toll—unless all receivers switch to the off-hours, which is the least likely case—plays no

role in incenting the carrier to switch to the off-hours. It should not surprise anyone that cordon time-of-day pricing does not provide the intended effect.

The analyses conclusively show that—since time-distance tolls enter into the marginal costs—carriers should be able to pass them to the receivers. However, since in order to induce the receivers to switch to the off-hours, the price signal reaching them must be greater than the receivers' costs associated with extending operations to the off-hours, the required time-distance unit tolls are extremely high (estimated in an example as five times larger than current costs). Due to the political unfeasibility of such tolls, it is doubtful that time-distance pricing could play a primary role in freight demand management, though it could be a complementary policy.

The key implication of all of this is that achieving the goal of switching a meaningful portion the regular hour truck traffic to the off-hours requires providing financial incentives to the receivers. A voluntary program in which the receivers commit to off-hour deliveries in exchange for a financial incentive is likely to attract a meaningful number of receivers. Since the corresponding carriers are likely to benefit from the switch to the off-hours—because of the lower costs and higher productivity—it is likely that the carriers would follow suit.

This alternative is clearly superior to either forcing all receivers to do off-hour deliveries—as it is done in Beijing, China—because it would lead to widespread cost increases; or using road pricing approaches that charge tolls to the carriers in the hope that they would pass toll costs to the receivers, and that these would lead the receivers to switch to the off-hours. As shown in the paper, the latter is not likely to happen because either the carriers have difficulties passing costs to receivers (under cordon time-of-day tolls); or because the unit time-distance tolls required to induce a behavior change would have be so high that are not likely to be politically feasible.

Obviously, a paradigm shift is needed. Should transportation policy makers be willing to embrace the fundamental findings of this research, it could open the door to more cost effective freight demand management that would be embraced by both carriers and receivers. Such freight industry friendly approaches could be a welcomed addition to the transportation policy toolkit.

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