# *Toward Comprehensive Policies of Urban Freight Demand Management: Empirical Evidence, Necessary Conditions, and Behavioral Micro-Simulation Results*

***José Holguín-Veras***
*Professor, Ph.D., P.E, Department of Civil and Environmental Engineering, Rensselaer Polytechnic Institute, JEC 4030, 110 8th Street, Troy, NY 12180, U.S.A, Tel: (518) 276-6221 Fax: (518) 276-4833, Email: jhv@rpi.edu*

***Michael A. Silas***
*Graduate Student, M.Sc., Department of Civil and Environmental Engineering, Rensselaer Polytechnic Institute, JEC 4033, 110 8th Street, Troy, NY 12180, U.S.A, Tel: (518) 276-3248 Fax: (518) 276-4833, Email: silasm@rpi.edu*

## Abstract

The purpose of this paper is to analyze the empirical, theoretical, and numerical findings pertaining to traditional freight road pricing, and comprehensive policies that target both receivers and carriers with the objective of increasing truck traffic during the off-hours. Such policies seem to be needed because the empirical evidence indicates that freight road pricing is of limited effectiveness in reducing urban truck traffic. 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 its first section, the paper discusses the empirical evidence from a major research project aimed at assessing the impacts of the Port Authority of New York and New Jersey's time of day pricing initiative on the behavior of commercial carriers. In its second section, the paper analyzes the effectiveness of comprehensive policies targeting receivers and carriers of goods in urban areas. This is based on the fundamental premise that truck traffic in congested urban areas could move to the off- hours, if and only if, the receivers of the cargoes are willing to accept off-hour deliveries. In its third section, the paper briefly discusses the necessary economic conditions needed to ensure that both freight carriers and receivers are willing to switch operations to the off-hours. In its final section, the paper presents the results of a behavioral micro-simulation that considers the joint behavior of carrier and receivers as they decide how to respond to transportation policies such as: tax deductions to receivers, freight road pricing, and freight road pricing combined with tax deductions to receivers. These results are then compared to the ones obtained from other techniques.

## Introduction

Freight transportation to urban areas is one of the causes of urban traffic congestion (Tri-State Transportation Campaign, 2005). This is because of the combined effects of producing a capacity constraint to the general traffic, and the frequent double parking of trucks. As a result, many major cities throughout the world have implemented road pricing efforts during the congested hours of the day. Additionally, other ideas are needed to be considered in reducing traffic congestion, including using economic incentives, to shift freight delivery operations to the non-traditional hours of the day.

The purpose of this paper is to analyze the empirical evidence, comprehensive policies, necessary conditions and simulated findings of urban freight demand management in competitive freight markets, with the objective of shifting truck traffic to the off-hours.

In its first section, the paper discusses the empirical evidence from a major research project aimed at assessing the impacts of the Port Authority of New York and New Jersey's time of day pricing initiative on the behavior of commercial carriers. In its second section, the paper analyzes the effectiveness of comprehensive policies targeting receivers and carriers of goods in urban areas. This is based on the fundamental premise that truck traffic in congested urban areas could move to the off- hours, if and only if, the receivers of the cargoes are willing to accept off-hour deliveries. In its third section, the paper briefly discusses the necessary economic conditions needed to ensure that both freight carriers and receivers are willing to switch operations to the off-hours. In its final section, the paper presents the results of a behavioral micro-simulation that considers the joint behavior of carrier and receivers as they decide how to respond to transportation policies such as: tax deductions to receivers, freight road pricing, and freight road pricing combined with tax deductions to receivers. These results are then compared to the ones obtained from other techniques.

## Empirical Evidence

Probably, the first study that collected behavioural data about the responses of the freight industry to road pricing is the Evaluation Study of the Port Authority of New York and New

Jersey's (PANYNJ) Time of Day Pricing Initiative (Holguín-Veras et al., 2005a). The primary focus was on the travel activities of commercial carriers (Holguín-Veras et al., 2006b). The study was based on a sample of current and former regular users of the PANYNJ's bridges and tunnels in the New York City and Northern New Jersey area. These current and former regular users were also classified as private and for-hire carriers.

A total of two hundred carriers were interviewed, and the key finding from this research indicated that carriers react to time of day pricing by collectively increasing levels of operational productivity, transferring costs to customers, *and* changing facility usage (Holguín-Veras et al., 2006b). Other findings from this survey designate that carriers' primary reasons for not changing their travel behavior are *lack of choice* (75.3% of truck trips), *lack of flexibility due to customers' requirements* (68.9%), and operational requirements to use *optimal delivery routes* (6.4%) (Holguín-Veras et al., 2006b). In general, it was also found that for-hire carriers and private carriers reported the same main reasons for not changing their behavior (Holguín-Veras et al., 2006b). Also, they exhibit some differences in that 72.3% of for-hire carriers stated that they cannot change their delivery schedule because of *customer requirements,* while 61% of private carriers reported the same reason (Holguín-Veras et al., 2006b). It was also found that 21.2% of for-hire carriers did not worry about toll increases since they transferred costs to their customers, compared to 16.3% for private carriers (Holguín-Veras et al., 2006b). Another key finding from this study indicated that trucks travel at designated times predominately because of customer requirements (Holguín-Veras et al., 2006b).

A fundamental conclusion of the PANYNJ study, and subsequent papers on the subject (Holguín-Veras et al., 2006b) is that road pricing by itself is of limited use to shift truck traffic to non-congested times of the day. This is primarily due to the understanding that not all carriers are able to transfer toll costs to their customers, and customer demands for goods to be delivered in a timely fashion. Furthermore, other efforts are needed to foster a shift in truck traffic to the off-hours. This could be done through the use of economic incentives and policies aimed at doing so.

## Comprehensive Policies

In order to understand some of the alternatives to time of day pricing, a study by the New York State Department of Transportation (NYSDOT) was conducted on off-hour deliveries in the New York City area, particularly focusing on the Manhattan area (Holguín-Veras et al., 2006b). The goal of this study was to understand how policies targeting receivers located in Manhattan, and carriers making deliveries to this area would affect the shift in delivery operations to the off-hour hours of the day. This was done with the intent of reducing truck traffic in the Manhattan area during normal daily business hours (Holguín-Veras et al., 2006b).

The first element of the project focused on outreach efforts targeting private sector receivers and carriers, which came in the form of: focus groups, in-depth interviews, and internet surveys (Holguín-Veras et al., 2005b; Holguín-Veras, 2006). From the focus group discussions, it was found that: (a) participants were unsure about the effectiveness of toll differentials or other incentives that might increase off-hour deliveries; b) truckers indicated that receivers are more concerned with accepting goods in a timely fashion than how many hours the truckers drive; and (c) receivers would only accept off-hour deliveries when given incentives to do so. The in-depth interviews indicated that restaurants are good targets for off-hour deliveries because of their extended hours of operations, and the receivers controlled the participation in off-hour activities because they control the delivery schedules for the carriers (Holguín-Veras et al., 2006a). The final component of the outreach efforts, the internet surveys, upheld the conclusions acquired from the focus group discussions and in-depth interviews, and suggested that avoiding parking fines, increased productivity, and tax incentives are elements that could make off-hour deliveries attractive to both receivers and carriers. The analyses done from the in-depth interviews also suggested that increased operation costs and lack involvement by receivers can prevent the participation in off-hour deliveries for both receivers and carriers.

Another element of the preliminary findings of the study focused on receivers, particularly those establishments that were classified as restaurants and drinking places, which amounts to more than 6,500 establishments. It was found from this analysis that: (a) 40% of the establishments have control over their delivery times, and 38% of the companies collaborate with their distributor on the decision of delivery times of their shipments; (b) restaurants accept more than 6 deliveries per day; (c) the number of deliveries that these receivers generated was a

function of the company location, number of employees, and number of customers; (d) restaurants were in favor of accepting off-hour deliveries in exchange for tax deductions (55.4% approval rate) and government subsidies (57.8% approval rate), but were less in favor of accepting off-hour deliveries for tax cuts (46.3% acceptance rate) and lower shipping charges (33.3% acceptance rate); and (e) receivers in commercial areas were more receptive to accepting larger and more time consuming deliveries during the off-hours (Holguín-Veras et al., 2006a).

Separate analyses of receivers and carriers were lastly conducted to understand the other factors that influenced their individual choices to participate in off-hour deliveries (Holguín-Veras et al., 2007a; Holguín-Veras et al., 2007b). For receivers, it was found that they displayed increased levels of willingness to participate in off-hour deliveries operations when given certain higher levels of economic incentives (e.g. tax deductions and shipping discounts); and receivers of: food, alcohol, wood/lumber, metal, paper products, and medical supplies are considered good market targets for fostering the implementation of an off-hour deliveries program in Manhattan (Holguín-Veras et al. 2007a). Carriers displayed the higher levels of willingness to participate in off-hour deliveries when given higher toll discounts and financial rewards for off-hour travel; and as the percentage of customers requesting off-hour deliveries increased so did the number of carriers likely to participate in these off-hour deliveries (Holguín-Veras et al. 2007b). Also, carriers of food, wood/lumber, metal, computers/electronics, textiles/clothing, and furniture are also considered good market targets for doing off-hour deliveries (Holguín-Veras et al. 2007a). It was also concluded that large traffic generators in Manhattan (i.e. Grand Central Terminal and Penn Station) are good target areas for an off-hour deliveries program (Holguín-Veras et al. 2007a, Holguín-Veras et al. 2007b). Other key findings from this analysis highlighted the descriptive statistics. These data analyses revealed that: (a) 4.09% of the goods accepted by receivers in Manhattan are during off-hour, while 11.76% of the goods delivered by the carriers are during the off-hour of the day; (b) receivers were most likely to accept off-hour deliveries when given tax deductions for one employee assigned to accept off-hour deliveries; and, (c) carriers were likely to participate in off-hour deliveries when given toll discounts for off-hour deliveries and financial rewards for making off-hour deliveries (Holguín-Veras et al. 2007a, Holguín-Veras et al. 2007b).

A product of this research project was the development of an outline of the receiver-carrier interactions that would determine the decision to participate in off-hour delivery activities, which

is displayed in Figure 1 (Holguín-Veras et al. 2007b). This figure shows that the receivers have the leading influence on the decision to do off-hour deliveries; this is because they are considered the customers in this situation (Holguín-Veras et al. 2007a, Holguín-Veras et al. 2007b). It also displays that factors like the off-hour deliveries incentives, operational decisions, and other price signals have influences on receivers' decision on delivery times, as well as the joint decision to participate in this activity made by receivers and carriers.

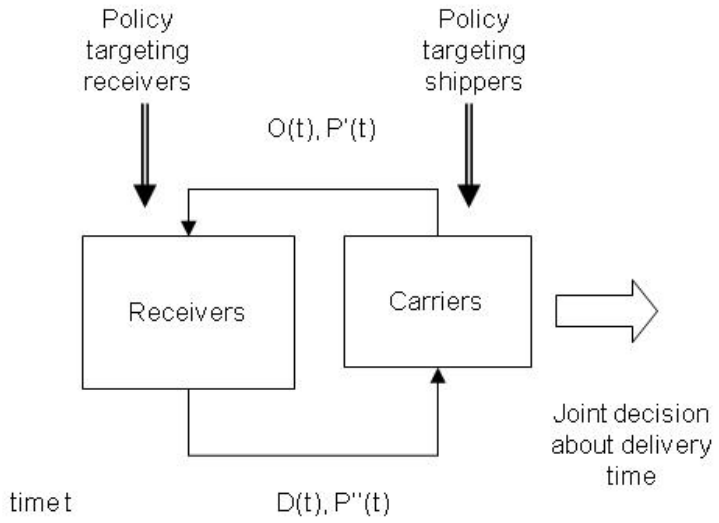


**Figure 1: Modeling schematic for understanding the receptiveness of off-hour deliveries (Holguín-Veras et al. 2007a).**

Other findings were found from the primary study efforts on the effectiveness of off-hour deliveries in New York City, which resulted from the analyses of larger and more diverse populations of receivers and carriers. The analyses done recognized that the willingness of carriers to participate in off-hour deliveries is dependent upon the participation of the receivers (Holguín-Veras et al. 2007a). This means that the higher the rate of participation in off-hour deliveries by receivers, the more likely the carriers would be to shift their delivery schedules to the off-hours of the day. Moreover, it was shown that the receivers' receptiveness to accept off-hour deliveries is a function of the economic incentive scenarios proposed, meaning that the higher the proposed incentive the more likely the receivers are to participate in such a program (Holguín-Veras et al. 2007a).

This study on off-hour deliveries has demonstrated the potential of how giving economic incentives to receivers could foster a shift of business operations and truck traffic to the off-hours, while also revealing classifications of receivers and carriers that may participate in such activities.

## Necessary Conditions

In order to understand the theoretical basis of the behavior captured in the data and analyses concerning the PANYNJ study, and the off-hour delivery project, a set of economic formulations were derived using game theory principles (Holguín-Veras, 2008). These conditions were based on the fundamental premise that, in order for off-hours deliveries to be implemented, both carriers and receivers must be better off. This enables to derive a set of necessary conditions for a variety of policy scenarios.

The primary set of conditions considered the situation where carriers and receivers jointly agreed to independently participate in off-hour deliveries. This could first happen when both stakeholders stand to make profits from these operations (Holguín-Veras, 2008). In addition to these conditions, policy variations were included to consider financial incentives given to receivers and freight road pricing being imposed on carriers, while also having the receivers sharing their incentives with the carriers. From these mathematical formulations, it was found that off-hour delivers could take place when the total incremental costs including the toll must be less than or equal to the sum of financial incentives given to an individual carriers by the receivers it delivers to (Holguín-Veras, 2008). This would allow both parties to make profits from the shift in delivery times. Furthermore, these circumstances considered carriers making multiple delivery tours, where it was found the cost for the number of off-hour tours and incremental costs would also have to also be less the sum of financial incentives given to an individual carrier by the receivers it delivers to (Holguín-Veras, 2008). Another sub case analyzed the situation where only freight road pricing is imposed, and carriers are able pass toll costs to their receivers. Under these conditions, it was found that off-hour deliveries could occur when the negative total incremental toll costs is greater than or equal to the sum of the incremental total costs for receivers and carriers minus the cost savings gained by the carriers (Holguín-Veras, 2008). This finding also held when considering multiple off-hour delivery tours.

Another scenario was mathematically analyzed considering the joint decision to participate in off-hour deliveries by companies participating in both private carrier and receiver operations. For this situation, off-hour deliveries are possible again when gross revenues exceed the total costs for receiver and carrier operations (Holguín-Veras, 2008). Also, it was found that off-hour deliveries could be an "all or nothing decision" when the differences in operational costs are known to be less during the off-hours. This may be due to higher levels of productivity (e.g., travelling, loading and unloading speeds), lower toll and receiving costs for companies with around the clock business operations, and companies able to make numerous off-hour delivery tours (Holguín-Veras, 2008).

Two other facility specific situations where off-hour deliveries could occur involve large traffic generators and areas using the PierPass system (Holguín-Veras, 2008). With these facilities, off-hour deliveries could become a common practice since they receive and ship large numbers of daily deliveries, which generates notable amounts of regular hour truck traffic that could be shifted (Holguin-Veras, 2007). Specifically, large traffic generators contain central shipping and receiving locations where deliveries can be stored at any time until business managers and carriers are able to retrieve these goods (Holguín-Veras, 2008). Also, PierPass facilities have shipping and receiving operations during all hours of the day, so shifting more operations to the off-hours could be feasible (Holguín-Veras, 2008).

These economic formulations fundamentally suggest that shifting truck traffic to the off-hours could occur when carriers and receivers stand to make profits from these operations. This could be done through the use of "financial incentives given to receivers willing to accept off-hour deliveries, combined with freight road pricing." Moreover, other circumstances like profit sharing between carriers and receivers, and carriers sharing toll costs with receivers should be considered in making off-hour deliveries beneficial for both stakeholders (Holguín-Veras, 2008).

## Behavioral Micro-Simulation of Carrier-Receiver Interactions

To apply the necessary conditions formulated by Holguin-Veras (2008), a behavioral micro-simulation environment was developed (Silas and Holguín-Veras, 2008). Its purpose is to understand how the use of economic incentives given to receivers and carriers, could influence carrier participation in off-hour deliveries, and subsequently, shift the amount of truck traffic in

urban areas from the regular hours to the off-hours. This framework is shown in Figure 2. Fundamentally, it assumes receivers and carriers make a sequential decision making process for participating in off-hour deliveries. The main modules in this behavioral micro-simulation, which are the components inside of the dotted box in Figure 2 are: the carrier-receiver selection process, the receiver behavioral simulation and carrier behavioral simulation. In this schematic, the decisions to participate in off-hour deliveries is first influenced by the given policy incentives (denoted $\Pi_r$ and $\Pi_c$). The receivers are able to take advantage of a tax deduction given for one worker to accept deliveries during the off-hour hours, and the carriers are able to take advantage of toll surcharge for their off-hour deliveries. Figure 2 resumes with a carrier-receivers selection process using a synthetic population of carriers to understand how the delivery scheduling of commodities are influenced, with receivers being located in a space resembling Manhattan, and the carriers being located in space resembling the state of New Jersey. This is consistent with the origin of the data used in this framework. Next, the following industry segments were considered: plastics, jewelry/art, chemicals, wood/lumber, medical supplies, non-alcoholic beverages, alcoholic beverages, petroleum/coal, stone/concrete, paper, printed material, computers/electronics, office supplies, textiles/clothing, metal, furniture, household goods, machinery, and food. The process starts first by having a single industry segment randomly selected from list previously mentioned. Next, a random carrier is randomly selected from the industry segment's population. Afterwards, using the selected carrier's number of stops, that number of receivers is selected from the corresponding industry segment. This is the set of customers that the behavioral simulation of receivers will be used for. The receivers then used the off-hour delivery discrete choice model involving tax deductions presented in Holguin-Veras, et. al, (2007a) to make a decision on accepting off-hour deliveries. The carrier will then use these decisions to estimate delivery costs during regular and off-hour, and subsequently make a decision on making off-hour activities. The carrier selected will then determine if making both regular hour and off-hour deliveries costs less than doing all regular-hour deliveries.

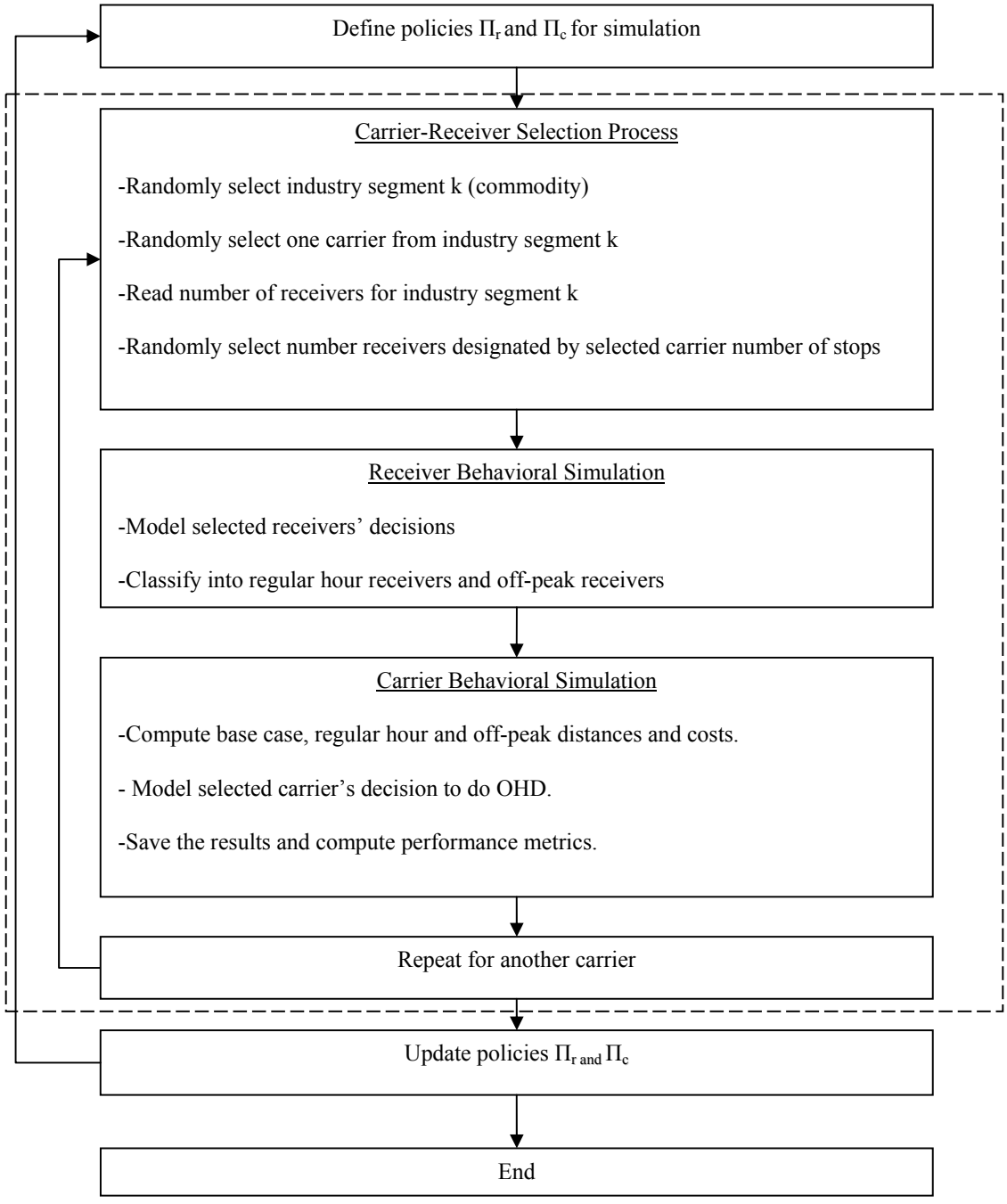


**Figure 2: Behavioral micro-simulation (Silas and Holguin-Veras)**

**Key Findings from Behavioral Micro-Simulation**

Since it is known that receivers are important in determining the participation in off-hour deliveries, it is essential to understand how economic incentives given to receivers will determine the participation of carriers. For that reason, the overall participation of carriers was analyzed as a function of tax deductions given to receivers, by running the behavioral micro-simulation for different levels of tax deductions given to receivers. The results are shown in Figure 3 (Silas and Holguín-Veras, 2008). The figure shows how the participation in off-hour deliveries by carriers increases as the tax deduction increases, and further confirms the usefulness of this economic incentive. For the sake of completeness, the results shown in Figure 3 are shown for tax deductions up to fifty thousand dollars, even though values that high are not likely to be considered. Finally, it should be noted that giving just ten-thousand dollar tax deduction to receivers for the acceptance of goods during the off-hours will provide about a twenty percent shift in carrier delivery operations (Silas and Holguín-Veras, 2008); this finding is helpful in verifying the necessary conditions set by Holguin-Veras (2008).

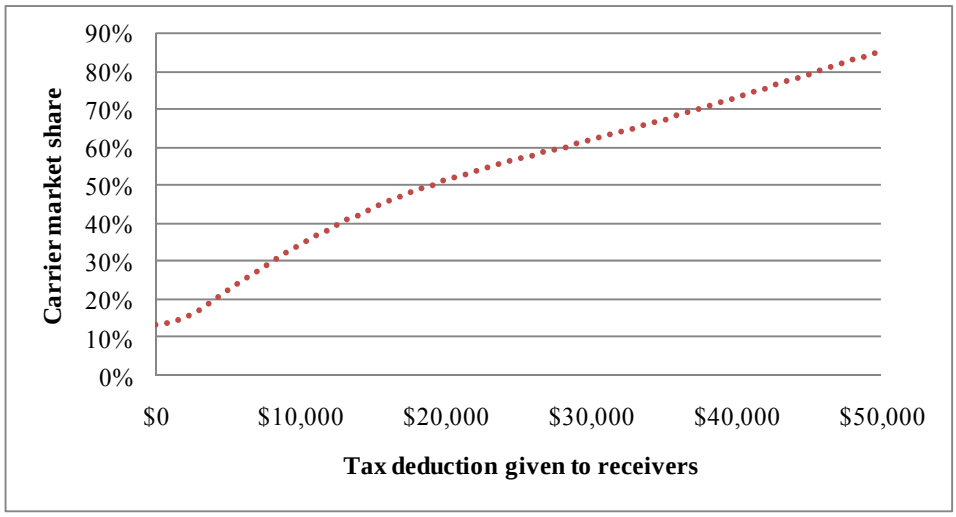


**Figure 3: Carrier market shares as a function of the tax deduction given to receivers**

Another analysis was aimed at understanding how freight road pricing, in the form of toll surcharges for regular-hour travel, would influence carrier participation in off-hour deliveries. The results shown in Table 1 mainly reveal that the market shares are changing non-systematically and are relatively close to the initial value of 11.71%, regardless of the toll surcharge (Silas and Holguín-Veras, 2008). This is because carriers are forced to pay the toll

surcharges when making all of their deliveries during the regular hour and when making regular hour and off-hour deliveries jointly. This finding has lead the authors to believe that toll surcharges alone are not enough in shifting delivery operations to the off-hours. Furthermore, these results support the mathematical formulations and necessary conditions set by Holguin-Veras (2007), and the findings of Holguin-Veras, et al. (2007a) and (2007b).

**Table 1: Carrier market share as a function regular hour toll surcharges**

| Toll Surcharge Per Axle | Carrier Market Share |
|---|---|
| $0 | 11.71% |
| $5 | 11.66% |
| $10 | 11.65% |
| $15 | 11.65% |
| $20 | 11.67% |
| $25 | 11.64% |
| $30 | 11.63% |
| $35 | 11.65% |
| $40 | 11.63% |
| $45 | 11.65% |
| $50 | 11.65% |

Also, an analysis was done to understand if tax deductions to receivers and toll surcharges for regular hour travel would foster more off-hour deliveries. The outcomes from this analysis are shown in Table 2, and it also reveals same oscillating patterns in market shares as previously mentioned, when examining the market shares horizontally (Silas and Holguin-Veras, 2008). However, when looking at the table vertically, it can be seen that off-hour participation is influenced by the tax deduction incentive (Silas and Holguin-Veras, 2008). This finding again supports the understanding that tax deductions are more significant in moving traffic to the off-hours than toll surcharges, which is consistent with the necessary conditions presented by Holguin-Veras, 2007.

**Table 2: Carrier market share as a function of toll surcharges and tax deductions to receivers**

| | Toll Surcharge Per Axle | | | | | |
|---|---|---|---|---|---|---|
| **Tax Deduction** | **$0** | **$1** | **$2** | **$3** | **$4** | **$5** |
| **$0** | 11.71% | 11.62% | 11.65% | 11.71% | 11.70% | 11.71% |
| **$5,000** | 15.30% | 15.28% | 15.24% | 15.29% | 15.30% | 15.32% |
| **$10,000** | 25.05% | 24.96% | 25.07% | 24.75% | 25.05% | 25.07% |
| **$15,000** | 34.80% | 35.22% | 34.75% | 34.99% | 34.88% | 34.78% |
| **$20,000** | 43.43% | 43.81% | 43.36% | 43.88% | 43.55% | 43.51% |
| **$25,000** | 51.53% | 51.11% | 51.30% | 51.47% | 51.16% | 51.56% |
| **$30,000** | 57.38% | 57.18% | 57.36% | 57.07% | 57.36% | 57.47% |
| **$35,000** | 62.30% | 63.00% | 62.51% | 62.57% | 62.62% | 62.21% |
| **$40,000** | 68.04% | 68.15% | 67.91% | 68.19% | 67.91% | 68.06% |
| **$45,000** | 73.88% | 73.66% | 74.04% | 74.04% | 74.02% | 73.88% |
| **$50,000** | 80.16% | 80.22% | 80.19% | 79.96% | 80.45% | 80.24% |

This behavioral micro-simulation framework was directly compared to behavioral models for carriers found by Holguín-Veras, et. al (2007b). When comparing the market share estimates of off-hour delivery participation from both approaches (displayed in Table 3) indicates that the behavioral micro-simulation's estimates are numerically higher than the discrete choice model approach as the tax deduction increases. This finding may be more numerically indicative in understanding carrier participation in this practice since this behavioral micro-simulation considers more practical dynamics than the behavioral models.

**Table 3: Carrier market share comparisons between the behavioral models and behavioral micro-simulation**

| Tax Deductions to receivers | Carrier Market Share from behavioral models (%) | Carrier Market Share from behavioral micro-simulation (%) | % Difference |
|---|---|---|---|
| $0 | 11.71% | 11.71% | 0.00% |
| $2,000 | 13.25% | 12.37% | -0.88% |
| $4,000 | 14.52% | 14.00% | -0.52% |
| $6,000 | 15.92% | 16.83% | 0.91% |
| $8,000 | 17.19% | 20.54% | 3.35% |
| $10,000 | 18.11% | 25.05% | 6.94% |

The behavioral micro-simulation framework introduced by Silas and Holguin-Veras (2008) was developed as a means of verifying the necessary conditions policy schemes formulated by Holguin-Veras (2008). This framework also demonstrates the effectiveness of using economic incentives to increase participation in off-hour deliveries, and consequently impacting truck traffic during normal business hours.

## Conclusions

The paper has tried to provide a comprehensive view of the freight industry's behavioural response to pricing and other more comprehensive policies. In doing so, the paper analyzed the behavioural data collected as part of the Evaluation Study of the Port Authority of New York and New Jersey's (PANYNJ) Time of Day Pricing Initiative, which is the first study that collected such data. The analyses reveal that: (1) a negligible portion of truck traffic moved to the off-hours of the day; (2) that only about 9% of the carriers could pass the increased tolls to the receivers; and (3) that about 70% of the carriers that could not change behaviour indicated that "customer requirements" prevented them from changing. This clearly indicates that carriers are the weak partner in the relation and that without receivers willing to move to the off-hours, there is nothing the carriers could do.

The paper then analyzed the potential of comprehensive policies targeting both carriers and receivers, specifically considering a toll surcharge to truck traffic during the regular hours, and a tax deduction to receivers willing to accept deliveries during the off-hours. The results clearly indicate that the tax deductions play a significant role in fostering off-hour deliveries. These results are consistent with findings obtained using economic formulations that express the necessary conditions for off-hour deliveries to be feasible.

The paper also discusses a behavioural micro-simulation developed to estimate the joint response of carriers and receivers. This micro-simulation is based on discrete choice models to estimate the behaviour of receivers, and an economic formulation to estimate the response of carriers. Some key findings are that: tax deductions to receivers willing to do off-hour deliveries are an effective way to reduce truck traffic in the regular hours of the day; and, that carriers closer to the study area are more likely to embrace off-hour deliveries.

Taken together the analyses in the paper provide a comprehensive view of the crucial facets of this problem. It is the authors' hope that these findings help pave the way to more effective policies to reduce truck traffic during the congested hours of the day.

## References


Holguín-Veras, J. (2006). Potential for Off-Peak Freight Deliveries to Congested Urban Areas Albany, NY, Rensselaer Polytechnic Institute, http://www.rpi.edu/~holguj2/OPD/OPD_FINAL_REPORT_12-18-06.pdf.

Holguín-Veras, J. (2008). "Necessary Conditions for Off-Hour Deliveries and the Effectiveness of Urban Freight Road Pricing and Alternative Financial Policies." Transportation Research Part A: Policy and Practice 42A(2): 392-413.

Holguín-Veras, J., K. Ozbay and A. D. Cerreño (2005a). Evaluation Study of the Port Authority of New York and New Jersey's Time of Day Pricing Initiative. http://www.rpi.edu/~holguj2/PA/index.html.

Holguín-Veras, J., N. Pérez, B. Cruz and J. Polimeni (2006a). "On the Effectiveness of Financial Incentives to Off Peak Deliveries to Manhattan Restaurants." Transportation Research Record 1966: 51-59.

Holguín-Veras, J., J. Polimeni, B.Cruz, N. Xu, G. List, J. Nordstrom and J. Haddock (2005b). "Off-Peak Freight Deliveries: Challenges and Stakeholders Perceptions." Transportation Research Record 1906: 42-48.

Holguín-Veras, J., M. Silas, J. Polimeni and B. Cruz (2007a). "An Investigation on the Effectiveness of Joint Receiver-Carrier Policies to Increase Truck Traffic in the Off-Peak Hours. Part I: The Behavior of Receivers." Networks and Spatial Economics 7(3): 277-295.

Holguín-Veras, J., M. Silas, J. Polimeni and B. Cruz (2007b). "An Investigation on the Effectiveness of Joint Receiver-Carrier Policies to Increase Truck Traffic in the Off-Peak Hours. Part II: The Behavior of Carriers." Networks and Spatial Economics (published online)(10.1007/s11067-006-9011-6).

Holguín-Veras, J., Q. Wang, N. Xu, K. Ozbay, M. Cetin and J. Polimeni (2006b). "The Impacts of Time of Day Pricing on the Behavior of Freight Carriers in a Congested Urban Area: Implications to Road Pricing." Transportation Research Part A: Policy and Practice 40 (9): 744-766.

Silas, M. and J. Holguín-Veras (2008). "A Behavioral Micro-Simulation for the Design of Off-Hour Delivery Policies." (in preparation).

Tri-State Transportation Campaign (2005). The Trucks are Coming: What Growing Truck Traffic Will Mean for New Jersey's Quality of Life. New Jersey Department of Transportation.