The Myths, the Truth and the Possible in Freight Road Pricing in Congested Urban Areas

José Holguín-Veras
Associate 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

Abstract

The paper analyzes the evidence regarding freight road pricing, complements it with game theoretic analyses, and concludes that moving trucks to the off-peak hours require comprehensive policies targeting key components of the supply chain (i.e., receivers and carriers). The paper shows that a request from receivers asking carriers to do off-peak deliveries is likely to have an impact across the entire carrier industry; while road pricing only impacts specific industry segments. This suggests that the most efficient way to move truck traffic to the off-peak hours is to provide financial incentives to receivers in conjunction with freight road pricing. Should a sufficient number of receivers be willing to accept off-peak deliveries, the carriers will follow suit. The paper considers a toll surcharge to finance off-peak delivery initiatives. The paper highlights and rebukes a number of myths related to freight road pricing in urban areas. Separating myth from truth and identifying the possible is a necessary condition to achieve the sound policy objective of moving towards a more balanced use of the existing transportation capacity.

Introduction

Road pricing in urban areas is predicated under the assumption that adjusting the private costs felt by drivers to match the social costs their driving produce would move the equilibrium solution to a situation in which deadweight losses are eliminated. In the case of automobile transportation, there is ample theoretical support and empirical evidence that, indeed, show that road pricing is an effective transportation demand management technique—that not only increases economic welfare but generates a significant amount of revenues that could support transportation investment.

In the case of freight transportation, however, the picture is not so clear. This is because urban freight transportation exhibits a number of rather unique features that call into question the effectiveness of road pricing. (The reader must note the emphasis on urban areas, as opposed to intercity travel conditions.) These features include: market imperfections of various kinds, contractual constraints, and, more importantly, interactions between agents that dampen the effectiveness of the price signals. It is important to mention that trucking industry representatives and advocates have long been in the record highlighting some of these issues, though only know the scientific community has access to behavioral data that could confirm or deny these claims.

This paper is based on two different research projects that, by a combination of fortuitous circumstances, were conducted almost in parallel providing complementary views of the behavioral impacts of pricing on the commercial trucking sector in the New York City (NYC) metropolitan area. The first project focused on the quantification of the behavioral impacts produced by the Port Authority of New York and New Jersey time of day pricing initiative (see Holguín-Veras et al., 2005b). The second project focused on the definition of comprehensive policies, i.e., targeting the entire supply chain, to induce a shift of commercial truck traffic to the off-peak hours (see Holguín-Veras et al., 2005b and 2005d). Taken together, these projects provide the first quantitative analyses of the observed impacts of pricing on commercial traffic; and the first stated preference analyses of policies that go beyond road pricing. To a great extent, the paper relies on previous publications (i.e., Holguín-Veras et al. 2005a, 2005b, 2005c and 2005d) to put together what seems to be the first comprehensive treatment of the subject. The findings from these projects shed light into the way forward toward new paradigms of transportation demand management for urban freight traffic.

The paper starts with a conceptual description of the fundamental interactions between the different agents involved in urban freight. The second section provides a brief description of the data collected by the two research projects, together with a summary of key findings. This is followed by a section in which myths and truths of freight road pricing are discussed. The conclusions at the end of the paper highlight the key findings.

THE FUNDAMENTAL INTERACTIONS

Freight traffic is the result of complex interactions among numerous agents, including: producers, shippers, freight forwarders, carriers (both private and common), receivers, regulatory agencies, to name a few. As a way to simplify this complex picture, one could re-define and re-group these agents so that the focus is placed on the functions most important for freight transportation modeling purposes: shippers, carriers and receivers. In the context of this paper, the "shipper" refers to the economic agent(s) associated with the production and the shipping of goods. This, of course, encompasses a multitude of different cases in which companies: produce and ship their own goods, produce goods and let another company handle the shipping, and so on. For purposes of this paper, all these different modalities will be considered part of the "shipper." The "carrier" represents the companies (e.g., transportation companies, Third Party Logistics providers) that are physically in charge of transporting the goods. As in the previous case, "carriers" represent a very heterogeneous group, ranging from: very small companies with a single truck to conglomerates that operate tens of thousands of trucks; carriers that serve the open market (the terms "common" and "for-hire" are used interchangeably in the paper to refer to this group) to carriers that only serve a parent or a related company (private), among others. (Although each of these denominations has different sub-groups, using the broad classes of "for-hire/common" and "private" provides sufficient level of detail to the purposes of this paper.) The final group, i.e., "receivers," represents the businesses that are the consignees of the cargoes. Again, this group of companies or individuals may represent the end users, simply be an intermediary between shippers and the end users, undertakes processing of the cargoes as an input to their production process, among other possibilities.

In this context, it is obvious that the interactions between shippers, carriers and receivers, must affect truck traffic patterns. Surprisingly, not much is known about how to effectively consider these interactions in the context of planning models. This is even more surprising given the fact that these interactions are at the very heart of two of the most important policy decisions in freight transportation planning: freight mode choice and freight road pricing. A solid understanding of the former is required to define policies aimed at reducing the dependence on trucking; and, in the same way, a thorough understanding of the latter is needed for the definition of efficient policies to move truck deliveries to the off-peak hours, when doing so makes sense.

Regarding the first choice process, there is ample econometric evidence that indicates that the interactions between shippers and carriers determine mode choice. This seems to be the result of the interactions between shippers and carriers by which shippers, after experimenting with various shipment sizes and receiving input (e.g., prices, level of service, damage rates) from the carriers, finally settle down on a given shipment size, as discussed in Holguín-Veras (2002). There is unanimous agreement in the literature on the subject (i.e., Chiang et al., 1980; Mc Fadden et al., 1986; Abdelwahab and Sargious, 1991; Abdelwahab, 1998; and Holguín-Veras, 2002), that freight and vehicle choices are best considered as part of a discrete-continuous choice problem in which the shipment size is the continuous variable and mode (or vehicle in the case considered in Holguín-Veras, 2002) is the discrete variable. The importance of the shipment size choice is so significant that Samuelson (1977, pp. 118-119) commented: "…the relevant transportation choice which a shipper makes is not simply a choice between modes, but a joint choice of mode and shipment size. In most cases, the shipment size is practically mode determining…. Hence, it follows that in freight demand modeling, shipment size and mode choice should always be modeled jointly." The econometric evidence suggests that the shipment size choice, in essence, determines mode/vehicle choice.

In this context, these interactions could be interpreted as a cooperative game. The reason why can be appreciated by constructing the corresponding payoff matrix (see Table 1) that shows the anticipated payoffs to each player for cooperating or not cooperating with the other agent. The resulting four quadrants, corresponding to the different combinations, are labeled by superscripted letters I, II, III and IV. The payoffs are indicated as a duplet with two signs, where a positive sign indicates a net benefit and a negative sign a net loss. The first sign in the duplet represents the payoff to the agent in the left of the matrix, while the second sign in the duplet represents the payoff to the agent on the top of the matrix. As shown in Table 1, the three quadrants (i.e., II, III and IV) involving some degree of non-cooperation between shippers and carriers have negative payoffs for both agents, because: (1) under typical market conditions, the non-cooperative carrier of quadrants II and IV would be sooner or later be replaced because its customers are not likely to be satisfied with its non-cooperative behavior; and, (2) the non-cooperative shipper of quadrants III and IV by not choosing a shipment size convenient to its carrier is likely to experience higher costs or lower quality of service. If both agents choose to cooperate with the other, as shown in quadrant I, both of them are likely to be better off. This is because a shipment size suitable chosen is likely to bring about lower transportation costs and better level of service because it would enable the carrier to take advantage of its strengths. In this context, cooperation is the only logical alternative and, for that reason, this is a cooperative game.

Table 1: Payoff matrix for shipper-carrier interaction

		Carrier	
	Strategy	Cooperative	Non-cooperative
Shipper	Cooperative	(+,+) (I)	(-,-) (II)
	Non-cooperative	(-,-) (III)	(-,-) (IV)

The other case, which is the main focus of this paper, pertains to time of travel and delivery time decisions in urban areas. In this case, receivers—by imposing delivery time constraints and by virtue of being the carriers' end customers—have a significant amount of power to influence the time of day at which trucks travel. It is obvious that without receivers willing to accept deliveries during the off-peak hours, the carriers cannot switch out of the peak hours. There shall be no doubt that carriers—everything else equal—would rather operate during the night hours than during the congested peak hours. The experience of Linens N Things, a retailer of household goods, provides a good example. According to the information provided to the author as part of an in depth interview, company executives mentioned that the average speed of their trucks jumped from 17 miles per hour during daytime to 34 miles per hour during the off-peak hours (the experiment took place during the 1984 Olympics in Los Angeles). Since the time component of the cost function is the one that dominates, such an increase in travel speed is expected to have had a significant impact in operating costs.

It is important, at this point, to make a distinction between common and private carriers. In the case of private carriers, that are those that only provide transportation service to a parent or related company, there is a significant degree of cooperation between the shipping and the receiving operations, in which what really matters is the overall performance of the operation (as opposed to the financial performance of one of the parts). This is because of the internalization of the benefits, which enable cross-subsidization between the carrier and the receiver operations. As a result, since the decision is made on the basis of the overall performance, game theoretic analyses do not apply because there is only one decision maker that decides what is best for the entire operation. It should not come as a surprise that the bulk of the companies that have implemented off-peak delivery operations (e.g., 7/11, Walmart, Linens N Things) have private carrier operations.

The case of common carriers is completely different because there are two players each trying to maximize profits. The payoff matrix for this case provides interesting insight into the nature of the dynamics between carriers and receivers. Table 2 shows the payoff matrix for the basic decisions associated with traveling and accepting deliveries during the regular, or the off-peak hours. As shown in Table 2, if carriers and receivers do not agree in the delivery time, both of them lose (quadrants II and III). As a result, no rational set of players would select quadrants II or III, simply because they would be worse off than in quadrants I and IV. This is because the carriers would not complete the job and get paid, and the receivers would not get the cargoes they ordered. As shown in Table 2, the payoff matrix is very different to the one discussed before because, in this case, there is no clear win-win situation. In the case of quadrant I, the receiver benefits because it receives the goods during normal hours when no additional staff is needed, though the carrier has to deal with the low productivity associated with traveling in congestion. The case outlined in quadrant II represents the situation in which the carrier benefits from the higher productivity of traveling during the off-peak hours, while the receiver faces the additional costs of accepting deliveries during the off-peak hours (e.g., staff, security).

Table 2: Payoff matrix for (common) carrier-receiver interaction

		Receiver	
	Strategy	Regular hours	Off-peak hours
Carrier	Regular hours	(-,+) (I)	(-,-) (II)
	Off-peak hours	(-,-) (III)	(+,-) (IV)

This means that the equilibrium solutions will be either in quadrants I or IV, where both players agree with the delivery time. However, which quadrant is selected, depends on which player has most market clout because there is no way to cross-subsidize. (In a perfect market, the carriers would adjust the rates to match their marginal costs. However, as discussed later in the paper, a number of market imperfections prevent this from happening.) Since, as a rule, the receiver is the dominant agent, because it is the client, it follows that in most of the cases the solution is in quadrant I. This is not to say that carriers do not have any power. As shall be seen later in the paper, some carriers do have some level of control to impose price increases and other measures that make receivers share the burden of road pricing.

Since from the societal point of view the most beneficial combination is the one in quadrant IV—because of the more balanced use of existing capacity—it follows that the only way to move the equilibrium solution to the socially optimal outcome is to provide the receivers with financial incentives to convince then to accept deliveries during the off-peak hours. These compensation schemes are absolutely crucial to the success of policies aimed at moving trucks to the off-peak hours. Although admittedly simplified, these payoff matrices capture the essence of the dynamics between the agents involved in this decision. The reason why other factors, e.g., price signals, were not included in the discussion is clarified later in the paper.

DESCRIPTION OF THE DATA SETS

The Port Authority of New York and New Jersey's Time of Day Pricing Initiative

On January 25, 2001, the Port Authority of New York and New Jersey (PANYNJ) approved a time of day pricing initiative at its six tunnels and bridges that varied the pricing on its facilities according to time of travel (peak hours, off-peak hours and overnight), vehicle type, and the payment technology used (cash, electronic toll collection) (see Table 3). It entered into effect three months later, on March 25, 2001. These crossings carry, approximately, an annual eastbound traffic of 126.6 million vehicles with a vehicle split of 91.2% autos, 6.5% trucks, and 2.3% buses. This is, by far, the largest application of road pricing in the United States.

Table 3: Toll rates before and after the time of day pricing initiative

Type of vehicle	Passenger cars		Trucks	
	Before	**After**	**Before**	**After**
Cash peak	$4.00 / car	$6.00 / car	$4.00 / axle	$6.00 / axle
Cash off-peak	$4.00 / car	$6.00 / car	$4.00 / axle	$6.00 / axle
E-ZPass peak	$3.60 / car	$5.00 / car	$3.60 / axle	$6.00 / axle
E-ZPass off-peak	$3.60 / car	$4.00 / car	$3.60 / axle	$5.00 / axle
E-ZPass overnight			$3.60 / axle	$3.50 / axle

Note: (1) Tolls are collected in the Eastbound (New York bound) direction only; (2) the peak hours are 6-9 AM and 4-7 PM on weekdays and 12 noon-8 PM on weekends; (3) the overnight period (trucks) is from midnight to 6 AM on weekdays; (4) the remaining hours are classified as off-peak hours (PANYNJ, 2005e).

The target population was defined as all carriers that have used any of the PANYNJ toll facilities on a regular basis (at least once per week) since the time of day pricing implementation in March 2001 (referred to as *current regular users*); and those individuals that regularly used toll facilities before March 2001 and stopped doing so about that time (referred to as *former regular users*). The population of interest included former regular users because they may have stopped using the PANYNJ facilities because of the time of day pricing initiative.

The target companies were selected from two groups: for-hire carriers (those that provide transportation service to the open market) and private carriers (those that provide transportation service to a parent or a related company). Sampling private carriers provides a unique challenge because almost all companies either manufacturing or transforming goods could potentially have a carrier operation. As a result of the resulting huge sampling universe the probability of finding valid respondents is really low. Considering the small likelihood to get suitable participants (i.e., that use the PANYNJ facilities at least one a week) from small private carriers, the sampling process focused on companies with at least 25 employees. For-hire carriers of all sizes were included in the sampling frame. Private and for-hire carriers were assumed to have different responses towards the changes in the toll structure because of their inherent differences in company attributes.

According to the definition of the target population, the sample should cover all areas where potential users locate. Ideally, this would include an adequate mix of carriers operating in the various market segments of the trucking industry including those that make thru trips through the PANYNJ facilities, as well as those that undertake relatively local operations. Unfortunately, collecting data using random telephone calls from companies making thru trips was found to be prohibitively expensive, because of the very low probability to find qualified respondents from the entire universe of companies (which includes, in essence, all companies operating in the United States and even Canada and México). As a result, the project team decided to collect the sample from those areas that concentrate the majority of users, i.e., New Jersey and New York. More specifically, the target counties included six counties in New Jersey (i.e., Bergen, Essex, Hudson, Middlesex, Passaic and Union) and two boroughs in New York City (i.e., Kings and

Queens). These counties were selected because previous studies determined they are significant generators, or transshipment locations, of cargoes destined to New York City (Holguín-Veras and Thorson, 2000).

During the early stages of the data collection planning process, the project team considered collecting data about the impacts of time of day pricing on receivers. At the end, unfortunately, it was decided against a receiver survey because, given funding and project schedule constraints, it would have forced a significant reduction in the carrier survey's sample size. It is clear however that future research should specifically target the role played by receivers in shaping the behavior of carriers as a response to road pricing strategies.

The survey had six major sections. The first one collected information on current regular users' operations, time of travel flexibility, including commodities types transported, frequency and number of stops made on a typical roundtrip for deliveries between New York City and New Jersey, among others. The second section focused on the respondents' level of awareness of E-ZPass features and the available toll discounts. The third section gathered data about the impacts of time of day pricing on carriers. It includes questions about changes in operations, trip frequency, number of stops, time of travel, duration of tour, shipment size, shipment charge, load factor, type of vehicles used, fleet size, and routes for deliveries. The fourth section was intended to assess the impact of different hypothetical combinations of toll rates and travel time savings (stated preference scenarios) on respondents' decisions about E-ZPass usage and travel schedules. The fifth section gathered respondents' input regarding the fairness of tolls, and other related issues. The sixth section captured the profile of the carriers in terms of company type, business type, fleet size and composition, the number of interstate drivers employed, and origins and destinations of deliveries.

A commercial data set containing company information was used as the sampling frame, from which a sample was drawn. Letters were sent to the companies in the sample asking them to participate in the survey. Companies willing to participate in the survey were contacted again to set up a time for the telephone interview.

The data collected contain 200 complete observations. Among them, 182 companies (91.0%) are current regular users of the toll facilities, and 18 companies (9.0%) are former regular users. From the view point of carrier type, there are 103 private carriers (51.5%) and 97 for-hire carriers (48.5%), which is consistent with national statistics. Of those surveyed, 165 companies (82.5%) are located in New Jersey; while 35 companies are from New York (17.5%). This geographic breakdown was, to a great extent, the result of the inherent difficulties in finding valid respondents from the New York area, which forced the project team to increase the relative proportion of New Jersey users.

The sample was expanded using the reported trip frequency as the expansion factor. In this way, the resulting statistics reflect the actual use of the facilities. Unfortunately, the lack of proper control totals prevented the implementation of a formal statistical expansion process aimed at eliminating any bias from the sample.

New York State Department of Transportation's Off-Peak Delivery Study

The main objective of this project was to define a set of policies—possibly targeting the entire supply chain—to increase off-peak hours by trucks to Manhattan. The only restriction placed on the type of policies was that participation in the proposed programs must be voluntary and that, as a result, regulatory measures forcing companies to do off-peak deliveries were not to be considered.

After a great deal of consultation with private sector representatives (including 17 in-depth-interviews, and an internet survey) the project team decided to focus on policies aimed at carriers and receivers. Two stated preference (SP) surveys targeting receivers and carriers were designed. These surveys contained questions aimed at gathering data about company characteristics, operational patterns and how the survey participants would react to different scenarios concerning off-peak deliveries (OPD). Once finalized, the surveys were conducted using computer aided telephone interviews (CATI). The interviews for both surveys were conducted from March 10 until April 4, 2005. During this time span approximately four hundred interviews (180 receivers and 192 carriers) were conducted.

The sample of receivers was drawn from a commercial database. A sample of the database was purchased containing information about company size, contact information of key officers, and number of employees among other company characteristics. The main objective was to collect data from those areas that concentrate the majority of the deliveries in NYC, which was previously identified to be receivers located in Manhattan. The sampling process focused only on receivers with more than five employees.

One hundred eighty (180) receivers of goods, all from Manhattan, representing fifty-four different Standard Industrial Codes, were interviewed. Nearly eight percent (14) of the companies interviewed are small, with five employees or less. Approximately, fifty-eight percent (104) of the companies hire five to twenty-four employees. Exactly fifteen percent (27) of the companies hired between twenty-five and forty-nine employees. Another fifteen percent (27) of the interviewed companies are considered large, with more than fifty employees. In addition, eight companies, the final four percent of the interviews, did not know how many employees they hire. All the companies interviewed are in either the wholesale or retail trade sectors.

Target carriers were selected from two groups: for-hire carriers (those that provide services to the open market) and private carriers (those that provide transportation service to a parent or a related company). Considering the low probability of getting suitable private carriers from small companies, the sampling process focused on private carriers with at least 25 employees.

Like in the data collection for receivers, the sampling frame used was a commercial database containing contact information and company characteristics. Cost considerations suggested collecting the sample from those areas that concentrate the majority of users. For that reason, the sampling process focused on carriers located in New Jersey and New York; more specifically, from the New Jersey counties of Bergen, Essex, Hudson, Middlesex, Passaic and Union, and from Kings (Brooklyn) and Queens in New York. These counties were selected because previous studies (Holguin-Veras and Thorson, 2000) determined they are significant generators, or transshipment locations, of cargoes destined to NYC.

THE MYTHS, THE TRUTH AND THE POSSIBLE

This section discusses a number of rather popular ideas that, implicitly or explicitly, pervade transportation policy. Each of these ideas is examined under the light of the data and findings from the projects described in the previous section.

Myth #1: "All trucks are created equal"

This idea is implicit in transportation policy because of the lack of explicit recognition that different truck types have different impacts in terms of the externalities they produce. Since a fundamental role of transportation policy is to foster the use of sustainable and socially beneficial technologies, not taking into account the differences among vehicle types may be considered a fundamental policy flaw. This section considers two, admittedly crude, estimators of the externalities produced by truck traffic: Load Equivalency Factors, LEF, (a proxy for the pavement deterioration produced by vehicles measured by the number of Equivalent Standard Axle Loads, or ESALs, produced by a given vehicle), and road space used, which is an estimate of the contribution to congestion. Tables in this section were originally reported in Holguín-Veras et al. (2005c).

It is frequently argued that the larger truck combinations produce more pavement deterioration than the smaller trucks, which is correct; and that, as a result, large trucks must pay higher tolls. The latter part of the statement is fundamentally wrong because what really matters, in terms of the economic efficiency that road pricing is supposed to foster, is which type of truck is the most efficient in terms of pavement deterioration with respect to the amount of cargoes transported (as opposed to which vehicle produces more pavement deterioration per truck).Table 4 shows estimates of LEF for different types of vehicles, together with estimates of the average payloads and the LEF/unit ton. As shown, although the 5 axle semi-trailer does produce more pavement deterioration than 2 or 3 axles single trucks, it is the most efficient type of truck because it is the one with the lowest value of LEF/unit cargo transported. There shall be no doubt that transporting 150 tons of goods with semi-trailers produce less pavement deterioration and congestion than transporting the same amount of cargo with 2 axle trucks. As the reader could verify, transporting 150 tons could be accomplished by either using 6 semi-trailers or 14 3-axle trucks. However, while the semi-trailers produce 11.4 ESALs, the 3 axle trucks produce 26.6 ESALS, i.e., more than twice the semi-trailers' amount.

Table 4: Load Equivalency Factors by Vehicle Type

FHWA Vehicle Class	Description	Load Equivalency Factor (LEF)	Average Payload (metric tons)	LEF / Payload
Passenger related vehicles				
1 *	Motorcycle	0.00002		
2 *	Passenger Car	0.0005		
4 *	Bus	0.9		
3	2 Axle-4 tire SUV	0.01	2.57	0.0038842
5	2 Axle-6 tire SUV	0.3	2.57	0.1165254
Commercial vehicles				
5 *	2 Axle SU truck	1.4	3.23	0.4333755
6	3 Axle SU truck	1.9	11.38	0.1669329
7	4 Axle SU truck	5.4	15.64	0.3452685
8	4 Axle – 1 Trailer truck	2.8	18.04	0.1552106
9 *	5 Axle – 1 Trailer truck	2.4	19.92	0.1205012
10	6 Axle – 1 Trailer truck	5.5	22.88	0.2403703
11	5 Axle - Multi-Trailer truck	2.3	19.30	0.1191906
12 *	6 Axle - Multi-Trailer truck	5.5	19.53	0.2815721

Notes:

(1) The LEFs were taken from NYSDOT (1994), with the exception of the value for vehicle class 8 which was estimated.

(2) The payloads were computed using VIUS 2002 data.

(3) Since the LEFs and payload come from different data, it is likely that the numbers are not perfectly consistent because the values of LEF depend on the payloads.

Table 5 shows similar computations for road space with respect to payloads. The road space was estimated assuming that it is equal to the summation of the vehicle length and a suitable value of spacing (assumed to be equal to 7m). As in the previous case, it is found that semi-trailers are the most efficient type of trucks. The author is confident that, if similar calculations are done for environmental impacts, similar results would be found.

Table 5: Road space vs. payload

FHWA Vehicle Class	Description	Road space used(m)	Average Payload (metric tons)	Length / Payload
Passenger related vehicles				
1	Motorcycle	2.0		
2	Passenger Car	5.8		
4	Bus	12.1		
Commercial vehicles				
5	2 Axle SU truck	14.6	3.23	4.5194878
6	3 Axle SU truck	16.1	11.38	1.4147627
9	5 Axle – 1 Trailer truck	23.7	19.92	1.1899491
12	6 Axle - Multi-Trailer truck	26.9	19.53	1.3771438

All of this suggests that toll policy should favor the larger truck combinations. However, in the vast majority of the cases, toll policy either disregards the differences between truck types, or penalizes the large truck combinations. Table 6 shows an econometric model estimated with pooled data from a random sample of tolls for different vehicle types and distances from 83 out of the 334 toll facilities in the US, for a total of 1,284 observations (Holguín-Veras et al., 2005c). The model, in essence, represents a snapshot of toll policy in the entire US.

Table 6: Cross sectional model of tolls vs. independent variables

a) Components of fixed tolls

Characteristic	Variable Name	Definition	Model 2	
			Coefficient	t-value
Intercept	Constant		3.32084	6.733
Facility type	DB	If facility is bridge=1, 0 otherwise	3.35297	10.061
	DT	If facility is tunnel=1, 0 otherwise	3.35159	7.095
Vehicle type	DBS	If bus then 1, 0 otherwise	0.89393	2.096
	DSUT	If single unit truck =1, 0 otherwise	0.78234	2.025
	DST	If semi-trailer =1, 0 otherwise	5.83282	10.403
	DLCV	If large combination vehicle =1	6.81027	11.338
Toll structure	DFQ	If frequent user=1, 0 otherwise	-1.48182	-2.322
	DALL	If same toll at all times=1, 0 otherwise	-4.34450	-9.916
	DOP	If tolls at off-peak time=1, 0 otherwise	-1.23013	-2.125
Interactions of vehicle type and geographic location	DBS_NE	Bus in North East	-1.94576	-2.936
	DST_SE	Semi-trailer in South East	-3.50391	-4.360
	DLCV_SE	Large combination vehicle in South East	-3.94956	-4.754
	DST_SW	Semi-trailer in South West	-1.63277	-2.205
	DLCV_SW	Large combination vehicle in South West	-2.91204	-2.823
Interactions of vehicle and ETC	DST_ET	Semi-trailer using ETC	-0.86185	-1.605
	DLCV_ET	Large combination vehicle using ETC	-1.39949	-2.601

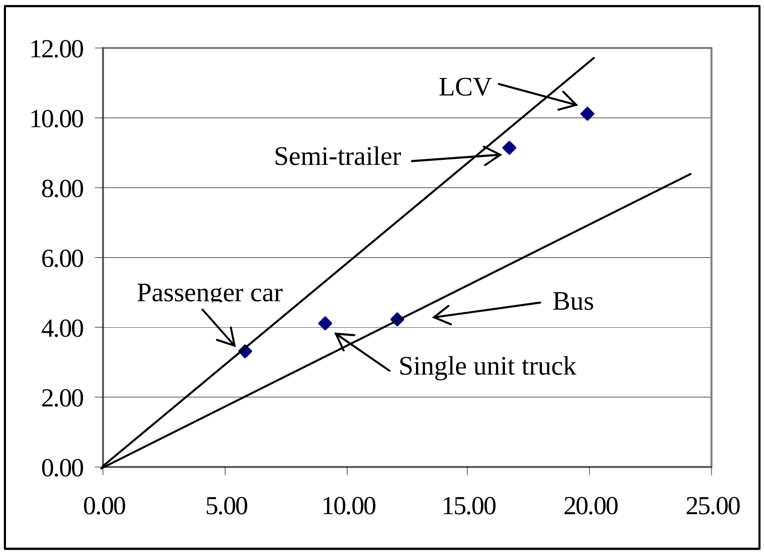
b) Components of variable tolls

Characteristic	Variable Name	Definition	Model 2	
			Coefficient	t-value
Distance of travel	DIST	Distance traveled on highway	0.053093	14.068
Interactions of vehicle type, geographic location and distance	DLCV_NE_D	(If Long Comb. Veh. in North East=1)*D	0.027710	2.113
	DST_SE_D	(If Semi-trailer in South East=1)*D	0.104397	12.408
	DLCV_SE_D	(If Long Comb. Veh. in South East=1)*D	0.139347	16.569
	DLCV_SW_D	(If Long Comb. Veh. in South West=1)*D	0.066556	1.869
Interactions of vehicle type and density	DBS_P	(If Bus=1)*P	0.000130	3.321
	DSUT_P	(If Single Unit Truck=1)*P	0.000145	4.164
	DST_P	(If Semi-trailer=1)*P	0.000475	12.696
	DLCV_P	(If Long Comb. Vehicle=1)*P	0.000598	15.515
Geography and density	W_P	(If in the West=1)*P	-0.000631	-5.8875
F-Value			140.820	
Adjusted R-squared			0.776	

Figure 1 show the fixed tolls as a function of vehicle size. (The coefficients of distance were not plotted simply because they are the same for all vehicles.) For reference purposes, straight lines linking the origin to the values corresponding to passenger cars and buses were added. Points below these lines indicate that the corresponding cost is relatively lower than the value for passenger car (or bus); while points above indicate the opposite.

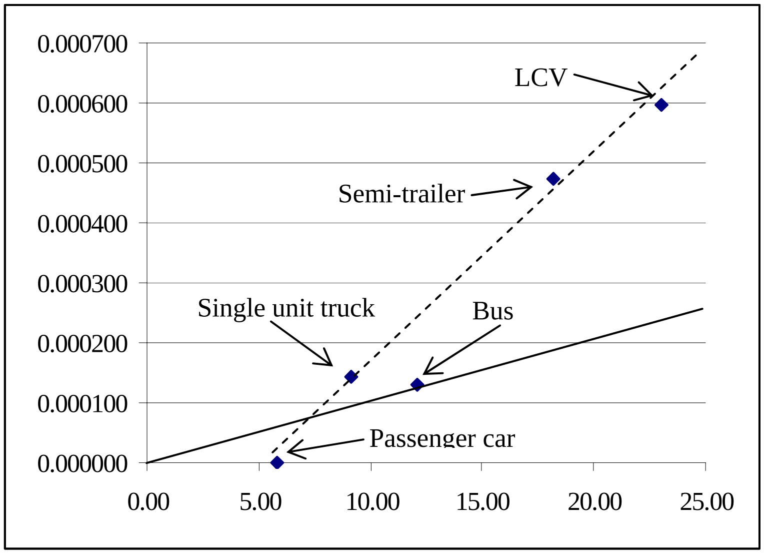
As shown in Figure 1, the fixed tolls corresponding to semi-trailers and long combination vehicles (LCVs) correlate well with the value for passenger car. This indicates that these three vehicles pay fixed tolls that are more or less proportional to their size. The exceptions are single unit trucks and buses that pay proportionally less than others.

Figure 1: Fixed tolls vs. vehicle length (m)



However, Figure 2 shows a completely different picture. As shown, while the passenger car tolls do not increase with population density (persons/square mile) and buses only increase mildly; the tolls for all trucks increase significantly. In other words, this suggests that the most congested areas of the country tend to penalize commercial vehicles more than proportionally to the congestion the trucks produce. This is particularly troublesome because population density is strongly associated with passenger traffic, and much less associated with truck traffic. Among other things, this finding gives credence to the complaints of trucking industry advocates that trucks pay proportionally more than other types of vehicles. As shown in Figure 2 the slope of the line connecting the coefficients for trucks (dashed line) is twice as steep as the one for buses.

Figure 2: Coefficients of population density vs. vehicle length



All of this suggests that, implicitly or not, freight toll policy in the US is guided by objectives different than welfare maximization because the tolls for commercial vehicles do not seem to be proportional to the externalities they produce. The author's conjecture is that a dual system is in place with tolls for commercial vehicles being determined on the basis of revenue generation objectives; while the tolls for passenger cars are determined on the basis of a mild form of welfare maximization.

Myth #2: "All carriers are created equal"

It is an understatement to say that the trucking industry is not homogeneous. Unfortunately, the level of awareness about these differences is very low. This is a major limitation because the various segments of the trucking industry exhibit fundamentally different behaviors as a response to transportation policy. These differences are a function of the type of operation, the market they serve, and company size among many others. The data collected for the PANYNJ project provide a great deal of information about how the various segments of the trucking industry reacted to time of day pricing. This section specifically discusses time of travel flexibility and makes a comparison between the attributes of carriers that changed behavior and those that did not in the aftermath of the PANYNJ time of day pricing initiative (after Holguín-Veras et al. 2005b).

The analysis of flexibility indicates that for-hire carriers are more constrained by their customers' schedules and, as a result, have much less flexibility than private carriers, which is consistent with the results discussed early. As shown in Table 7, the average flexibility window reported by those that have some flexibility (i.e., 26.6% of private and 25.1% of common carriers), while private carriers could arrive about 80 minutes later, and about 55 minutes earlier; for-hire carriers could arrive only about 26 minutes later, and about 24 minutes earlier. This should not come as a surprise because, as discussed before, private carriers enjoy more of a cooperative relationship with their receivers than common carriers. This implies that for-hire carriers are less sensitive to tolls because they have less flexibility to change time of delivery.

Table 7: Time of travel flexibility by carrier type (minutes)

Carriers	Late Arrival Flexibility	Early Arrival Flexibility
Private Carriers	79.0	55.1
For-Hire Carriers	26.1	23.7
All Current Regular Users	48.8	37.3

Note: The table is based on the 26.6% of private and 25.1% of common carriers that indicated having some flexibility to change time of travel.

The data show statistically significant differences in the company characteristics between the carriers that changed behavior and those that did not. Carriers that changed behavior are more likely to: (a) focus on full truckload services; (b) employ relatively fewer interstate truck drivers; and (c) venture in the areas out of New Jersey and New York doing long haul trips. The results of statistical tests are shown in Table 8. The distributions of origins and destinations of shipments indicate that the carriers that changed their behavior are more likely to originate in areas other than New Jersey and New York and deliver their shipments to the areas outside the Mid-Atlantic region (implying that they use the PANYNJ facilities for thru trips). As shown in Table 8, 28.0% of carriers that changed behavior transported shipments that originated in areas other than New Jersey and New York, which is much higher than the proportion among those that did not change (9.9%). Meanwhile, 30.4% of carriers that changed behavior transported cargoes to areas outside the Mid-Atlantic region, while only 16.2% of those that did not change did so. The analyses of origin-destination patterns suggest that the segment of the carrier industry most impacted by the time of day pricing initiative is the group of companies that use the PANYNJ facilities to make thru trips.

Table 8: Carriers that changed behavior vs. that did not change

Attribute	Changed behavior	Did not change	Statistically significant at 5% level?	Test used
% of FTL operators	73.6%	25.3%	Yes	Normal test for sample proportion
Interstate drivers (mean)	34.2 drivers	39.3 drivers	Yes	Normal test for sample mean
% of carriers transporting shipments with origins other than New Jersey and New York	28.0%	9.9%	Yes	Normal test for sample proportion
% of carriers transporting shipments with destinations other than the Mid-Atlantic region	30.4%	16.2%	Yes	Normal test for sample proportion
Fleet size (mean)	51.6 trucks	54.5 trucks	No	Normal test for sample mean

Myth #3: "All commodities are created equal" a.k.a. "We don't care about the cargo"

As a corollary of myth #2, one could be tempted to believe that the type of cargo transported is not relevant to transportation planning. This could not be farther from the truth. The type of commodity transported is an important factor in the vast majority of choice processes, for a number of different reasons. An obvious one is that different commodities have different operational requirements that, in some cases, require the use of specialized equipment, e.g., liquid cargoes. As a result, freight carriers tend to focus on those market segments more consistent with the equipment they own. A less obvious factor has to do with the nature of business relations. Many freight carriers develop business relations with specific customers, which lead them to know other customers in the same line of business; and, over time, the trucking company may end up focusing on a particular market segment, for purely historical reasons. As a result of these influences, the commodity type is routinely found to have a statistically significant role on choice processes pertaining to trucking operations. Holguín-Veras (2002), for instance, found that the type of commodity had an important role in the selection of the type of truck to be used. Similarly, McFadden et al. (1986) found that the type of commodity played an important role in freight mode choice.

This is because the commodity type is an excellent proxy for the industry segment in which the company operates. In this context, it is likely that a company transporting jewelry will exhibit an entirely different response to pricing than a company that specializes on electronics or cotton waste. Econometric evidence supporting this is discussed later in the paper.

Myth #4: "Truckers love to drive in congestion"

This assumption is implicit whenever transportation planners and policy makers fail to realize that <u>truckers travel during the congested hours of the day simply because their customers demand it.</u> Of course, truckers do not like to drive in congestion. This shall be obvious given the fact that their travel time values could be several times the travel time value for passenger traffic. There is no hope to define effective policies to move truck traffic to the off-peak hours until transportation policy acknowledges the constraints placed by the receivers of goods on delivery times.

The PANYNJ survey asked current regular users that did not change behavior the reasons why they did not react to time of day pricing (Table 9, after Holguín-Veras et al. 2005b). The largest group of reasons is that *they do not have a choice* (75.3% of truck trips) because *they cannot change schedule due to the customers' requirements* (68.9%) or *they must use the quickest route* (6.4%). A large proportion of carriers did not change their behavior because *the travel cost (including tolls) is paid by someone else* and thus they do not need to worry about the toll change (19.8%). Some of them said *customers absorb costs*, or *the cost is paid by shippers or receivers*. (These results are consistent with the fact that the same survey found that only 26.6% of private carriers and 25.1 of common carriers had some flexibility of time of travel.)

In general, for-hire carriers and private carriers reported the same main reasons for not changing their behavior: they either do not have flexibility (due to their schedule or route constraints) or their costs are paid by someone else. On the other hand, they exhibit some differences. For-hire carriers seem more likely to be constrained by their schedules; while private carriers tend to be less willing to change their routes. 72.3% of for-hire carriers cited *cannot change schedule due to customer requirements* while approximately 61% of private carriers reported the same reason. It was also found that a larger proportion of for-hire carriers (21.2%) did not worry about toll increase change since they transferred costs to their customers, compared to 16.3% for private carriers.

Table 9: Reasons for not changing travel behavior

Reasons	For-hire carriers	Private carriers	Carriers that did not change
No flexibility:			
Cannot change schedule due to customer requirements	72.3%	61.0%	68.9%
Must use quickest route	3.3%	13.6%	6.4%
Cost paid by others:			
Customers absorb costs	19.1%	15.9%	18.2%
Cost paid by shippers	0.0%	0.4%	0.1%
Cost paid by receivers	2.1%	0.0%	1.5%
Small price difference/can afford it	0.2%	6.1%	2.0%
No change in off-peak travel cost	0.3%	0.4%	0.4%
Do not know/Refused	2.6%	2.5%	2.6%
Total	100.0%	100.0%	100.0%
Total truck trips	**573**	**245**	**817**

Myth #5: "Truckers cannot react to pricing"

Trucking industry representatives argue that carriers cannot react to road pricing because they have to travel when the customers demand it. (The reader should notice the symmetry between the opinions of the trucking industry and transportation professionals.) The truth of the matter, on the basis of the evidence discussed in the paper, is that carriers could indeed react to pricing. However, the nature of this reaction may not be what one would expect. The PANYNJ data indicate that 36 carriers (20.2% of truck trips) changed behavior (including shipping charges as a behavioral change) because of the time of day pricing initiative. Excluding increases in shipping charges as a behavioral change, the percentage of the traffic that changed behavior becomes 19.3%. This includes 31 current regular users that changed behavior in different ways though still continuing to use the PANYNJ facilities (15.5% of carriers and 17.7% of truck trips); and 5 former regular users who cited tolls as the key reason to stop using the facilities (2.5% of carriers and 2.5% of truck trips).

The most striking feature of the carriers' behavioral responses to pricing is their multidimensional nature, which included fifteen different individual behavioral changes. Table 10 shows the individual behavioral changes reported by the carriers re-grouped in three different strategies: *Changes in facility usage* includes all behavioral changes that imply changes in the amount of use of the facility. *Productivity increases* considers all behavioral changes that primarily bring about increases in efficiency and productivity, e.g., to start using electronic toll collection (E-ZPass). Finally, *Cost transfers* includes behavioral changes by which cost is transfer to the end customer.

Table 10: Major combinations of strategies

Combination type	Facility Usage	Productivity	Cost	Total trips/day	%
1		✔		93	42.8%
3	✔		✔	60	27.6%
5	✔	✔	✔	42	19.3%
2			✔	11	5.1%
4	✔	✔		10.4	4.8%
2		✔	✔	1	0.5%

The statistics from Table 10 have been rearranged in Figure 3 to make it easier to understand how the carriers reacted to the time of day pricing initiative. Figure 3 shows the pure strategies, i.e., those that are implemented in combination with other strategy groups, as the vertex of a triangle. Two-dimensional combinations of strategy groups are represented as the mid points of the sides of the triangle; while the combination involving all three strategy groups is shown as the center of the triangle.

As shown in Figure 3, the single most important combination is to only implement *Productivity increases* (42.8%) which is shown as the lower left vertex of the triangle, followed by *Cost transfer* plus *Changes in facility usage* (27.6%), and *Productivity increases* plus *Cost transfer* plus *Changes in facility usage* (19.3%) that taken together represent 90% of all trips. It is interesting to note that no carrier implemented changes in facility usage as the sole strategy, which is what microeconomic theory predicts. In all cases, *Changes in facility usage* are implemented in combination with other strategies.

Figure 3: Major combinations of strategy groups

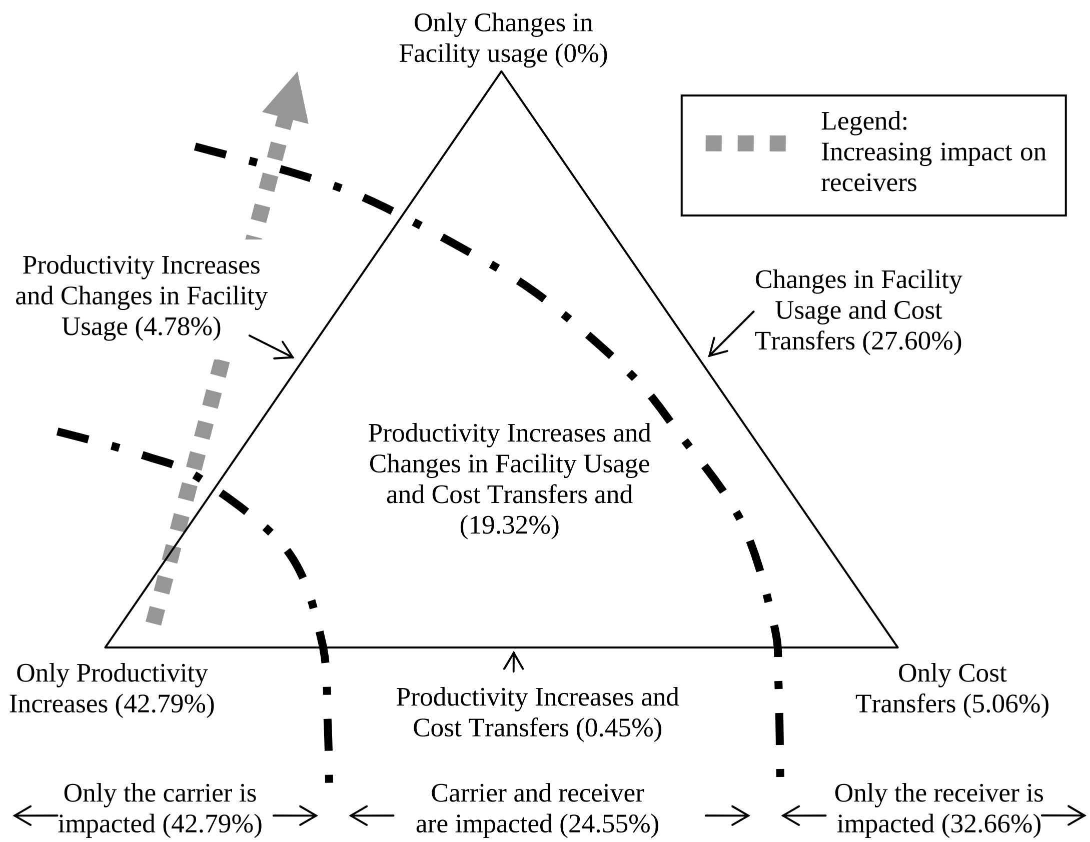


Figure 3 suggests the existence of three different situations. The first one represents the cases in which the carriers implement strategies that enable the carriers to absorb the impacts of pricing, while insulating the receiver (with 42.7% of trips). At the other end of the spectrum, one finds the group of carriers that implement strategies that primarily impact the receivers (with 32.66% of trips). Somewhere between these groups, there are carriers that implement strategies that affect both their own operations and their receivers' (the remaining 24.55%).

This suggests that the fundamental difference between these groups is related to the balance of power between receivers and carriers. In this context, if the balance of power favors carriers, it is likely that policies that transfer most of the impacts to receivers be implemented. At the other end of the spectrum, if receivers dominate the relationship, the carriers have no choice but focusing on strategies, such as *Productivity increases*, that while insulating the receivers enable them to mitigate the impacts of time of day pricing. A situation in between represents the case of carriers to implement changes that, in different ways, to share the impacts with the receivers.

Myth #6: "Road pricing is THE solution to get rid of those damned trucks"

The analyses of the data collected by the two studies discussed in this paper lead the author to believe that road pricing is not THE solution to freight demand management in urban areas, though it is part of the solution. The key reason is that the price signal reaching the receivers—that as discussed before are the key players—is too weak to be effective. This is no small matter. The fundamental assumption of freight road pricing is that the carriers would react to the price signal by moving to the off-peak hours. The truth of the matter is that only specific segments of truck traffic may have some flexibility. In the case of empty trucks—that typically represent 30-40% of the total truck traffic—the decision about time of travel is usually the truckers'. As a result, relatively speaking, they may exhibit more flexibility. Long haul traffic traveling thru an urban area is also likely to exhibit some flexibility simply because they could (possibly) change routes and still meet customer requirements.

However, in the case urban delivery trucks, the receivers are usually the key decision maker. Data collected as part of off-peak delivery project indicate that time of delivery decisions are made the receivers in 40% of the cases, jointly between the carrier and the receiver in 38% of the times, and by the carrier in the remainder 22% (Holguín-Veras et al. 2005d).

In this context, receivers would only react to road pricing and consider off-peak deliveries if and only if a strong price signal reaches them. However, two factors work against this from happening. The first factor is that the price signal gets diluted in the way to the receivers and that, even in those cases where the full price signal reaches the receiver, it is of no consequence when compared to the marginal costs of accepting off-peak deliveries (e.g., overtime costs, security, electricity). The estimates of the additional costs to receivers from accepting off-peak deliveries indicate that one hour of operation during the off-peak hours would cost the typical receiver in excess of $21.00/hour (assuming $8/hour in wages, indirect cost rate of 100% and 36% fringe benefits) and, possibly, and additional $3-4/hour for electricity, security etc. This implies that, in order for freight road pricing to be effective, the price signal reaching the receiver has to be larger than $25.00. However, taking into account that the average number of deliveries per truck in urban areas is about 6 deliveries per tour (data from Denver suggest the average is 5.6 stops/tour, see Holguín-Veras and Patil, 2005), and that the receivers are likely to know the carrier is delivering to other clients, it can be expected that receivers would not agree to pay more than what they perceive is their fair share of the tolls. Assuming that a carrier simply passes the tolls to six receivers, the original toll must be at least $150/truck to translate into a $25 charge to each receiver (assuming no gaming behavior). Since tolls that high are likely to be politically unfeasible, it follows that freight road pricing by itself will not be effective in switching trucks out of the peak hours.

A second factor is related to market imperfections that plague the trucking industry. The most obvious one is the way in which rates are usually agreed upon. The bulk of the rates are distance-based tolls that do not take into account costs based on time of travel. As a result, there is no contractual basis to transfer time of day tolls to the customers. As a result, carriers frequently find themselves having to absorb toll costs until they renegotiate their contracts. At that point, the receiver may face a rate increase, albeit a diluted one because of the time that has elapsed between the enactment of the tolls and the time the new contract is in place (because of the opportunity costs of the capital that would have been accrued between these two events).

To this effect it is illustrative to discuss the findings from the projects considered in the paper. The PANYNJ data indicate that carriers were only able to transfer costs to their customers in 9.0% of the cases (most likely, due to contractual constraints such as distance based rates that do not take into account time of travel), and lack of market power on the part of the carriers (see Holguín-Veras et al. 2005b). The average increase in shipping charges (all carriers) was 15.5%, which is generally lower than the toll increases (50% increase to cash tolls, 66.7% increase to E-ZPass peak tolls, 38.9% for E-ZPass off-peak tolls, and 2.8% decrease in E-ZPass overnight tolls). However, since it is very likely that the 15.5% increase was transferred to different customers, the carriers are expected to transfer the full toll cost to their customers. Interestingly, more private carriers (12.2%) increased shipping charges than for-hire carriers (7.3%). However, the magnitudes of the increases are significantly different: private carriers increased shipping charges in average of 11.0%, while for-hire carriers increased their shipping charges by 18.5%. This suggests that private carriers can more easily transfer the toll costs to their customers (usually another part of the company) than for-hire carriers. However, when for-hire carriers are able to transfer the toll costs their increases are significantly more aggressive than the ones implemented by private carriers.

It is not difficult to envision a situation in which some carriers benefit from the toll increase. For instance a five axle semi-trailer that delivers to six different customers experienced a toll increase of $10.00. Assuming that the original shipping charge to each customer was $25.00, an increase of 15% (average of the sample) translates into an increase in gross revenue of $22.50 (15% x $25 x 6 customers); which implies that the carrier makes money out of the toll increase. In fact, an executive of a regional trucking association and a number of truck dispatchers that participated in a focus group admitted to making money from tolls.

Truth #1: "Comprehensive policies targeting key elements of the supply chain are needed"

It shall be clear by now that freight road pricing as a demand management tool is not likely to be as effective as most transportation planners expect, and that expanding the scope of the supporting policies is absolutely necessary. This broadening of the scope should take advantage and acknowledge the interactions between carriers and receivers.

Central to this objective is the payoff matrix discussed before, i.e., Table 2. Short of regulatory approaches mandating off-peak deliveries in urban areas, understanding the corresponding policy implications is a sine equa non condition for the development of transportation policies able to manage truck traffic flows. As discussed before, if a sufficient number of receivers decide to accept off-peak deliveries, in all likelihood, truckers will follow suit. Needless to say, if this does not happen and the carriers have to maintain day and off-peak operations they are likely to oppose the idea because of the extra costs associated with the dual operation. Assuming that off-peak deliveries are deemed beneficial to Society, it is clear that proper financial incentives must be in place for them to accept off-peak deliveries. This section discusses example of alternative policies aimed at increasing the amount of both receivers and carriers doing off-peak deliveries.

The analyses discussed in the previous section are confirmed by the results of econometric modeling conducted using the SP data collected as part of the off-peak delivery project. Table 11 shows the model estimated for the scenario in which a tax deduction is offered to receivers willing to accept off-peak deliveries. As shown, while the tax deduction increases the likelihood of receivers deciding to accept off-peak deliveries, the receivers of wood/lumber, alcohol, paper, medical supplies, food, printed material and metal, are particularly sensitive to this policy.

Table 11: Best binary logit model for receiver's tax deduction scenario

Variable	Name	Coefficient	T-value
Utility of off-peak deliveries:	C1CHOICE		
A tax deduction in any employee assigned to OPD	TDEDUCT	8.392E-05	1.410
Reasons for not receiving OPD			
No access to building/freight entrance after hours	REASON1	-1.234	-1.571
Interferes with normal business	REASON2	-0.591	-1.208
Additional costs to the business if accepting more OPD	COST	-0.888	-3.232
Policy interaction terms			
Tax deduction for Wood/lumber	TDCOM8	6.968E-04	2.219
Tax deduction for Alcohol	TDCOM4	4.356E-04	2.209
Tax deduction for Paper	TDCOM9	2.627E-04	2.988
Tax deduction for Medical supplies	TDCOM22	2.598E-04	3.188
Tax deduction for Food	TDCOM2	1.875E-04	3.973
Tax deduction for Printed Material	TDCOM21	1.652E-04	1.802
Tax deduction for Metal	TDCOM13	1.415E-04	1.410
Other interaction terms			
Number of employees in a branch facility	BRANEMP	9.867E-03	1.612
Utility of no off-peak deliveries:			
Alternative specific constant	CONSTANT	1.599	4.151
R^2	0.172		
Adjusted R^2	0.140		

Table 12 shows the model for the scenario in which carriers were asked if they would do off-peak deliveries if a given percentage of their customers request it, and if they could save on tolls by traveling during the off-peak hours (both the percent of customers and the toll savings were experimental variables). The reader is suggested to focus on the two shaded areas of the table. As shown, the percent of customers is a strong explanatory variable that impacts all carriers, which is obvious given the fact that the receivers are the customers. In contrast, toll savings only play a role in specific segments of the carrier industry. As shown, only the carriers transporting petroleum/coal, wood/lumber, food and textiles/clothing were found to mildly sensitive to tolls. These are either non-perishable, low valued cargoes, or cargoes destined to receivers (restaurants) that tend to be open during the off-peak hours.

In other words, while a request from the receivers has the potential to impact the entire carrier industry; toll savings only play a role in four different market segments. These results strongly suggest that comprehensive policies targeting both receivers and carries are needed to induce a significant shift of truck traffic to the off-peak hours.

Table 12: Best mixed logit model for carrier's road pricing scenario

Variable	Name	Coefficient	t-value
Utility of off-peak deliveries:	C4CHOICE		
Percentage of customers requesting OPD	PCUST	0.017	2.912
Number of employees	DBSEM	0.007	1.928
Primary line of business			
Shipper	SHIPPER	1.464	3.994
Third Party Logistic Provider	THIRDPL	3.484	4.752
Trucking companies	TRUCKING	1.649	4.654
Warehouse	WAREHOUS	0.831	2.041
Mover	MOVER	1.389	2.326
Number of truck drivers	TRUCKD	0.027	2.787
Total trips to Manhattan	TTRIPS	0.047	1.371
Reasons for not making OPD			
Overtime costs	REASON1	-0.737	-1.207
Union regulations	REASON2	-0.850	-1.798
No access to buildings at that time	REASON5	-1.167	-2.419
Parking infractions in Manhattan per driver per month			
Nothing	FINE0	-1.083	-2.600
From $1-$100	FINE100	-0.521	-1.665
Policy interaction terms			
Toll savings for Petroleum/coal	TOLCOM10	0.440	1.606
Toll savings for Wood/lumber	TOLCOM8	0.340	1.912
Toll savings for Food	TOLCOM2	0.209	2.733
Toll savings for Textiles/clothing	TOLCOM6	0.217	2.022
Other interaction terms			
Total Trips for Plastics/rubber	TTCOM12	0.826	2.043
Total Trips for Furniture	TTCOM7	-0.064	-1.107
Total Trips for Food	TTCOM2	-0.174	-1.516
Total Trips for Machinery	TTCOM14	-0.132	-1.941
Total Trips for Households goods/various	TTCOM16	-0.174	-1.516
Total Trips for Alcohol	TTCOM4	-0.493	-3.264
Utility of no off-peak deliveries:			
Alternative specific constant	CONSTANT	2.336	4.757
R^2	0.194		
Adjusted R^2	0.146		

Myth #7: "There is no money to do that"

It shall be clear by now that comprehensive policies encouraging receivers to accept off-peak deliveries and discouraging carriers to travel during the peak hours are needed. This leads to the practical question of how to fund the financial incentives to receivers willing to accept off-peak deliveries.

The idea proposed in this paper entails using toll revenues to subsidize the receivers willing to accept off-peak deliveries. For illustration purposes, consider the effect of a toll surcharge of $5 to trucks traveling in the regular hours. Assuming 8.2 million trucks/year, which is the truck traffic at the PANYNJ facilities, such traffic would generate approximately $40 million dollars (allowing for some demand contraction). On the other hand, a $10,000 tax deduction to restaurants accepting off-peak deliveries would lead to 20% of the restaurants switching from the regular to the off-peak hours (Holguín-Veras et al. 2005d), leading to a total truck traffic deduction in the day hours of 1.3 million trucks/year in the New York City network (the reader is advised to keep in mind that, according to the data collected in these projects, restaurants receive between 6 to 8 deliveries/day) for a total cost to taxpayers of $13 million/year.

The remainder of the toll revenues could be used, very effectively, to incentivate large traffic generators (e.g., Grand Central Terminal, colleges, government offices)—some of them receiving hundreds of deliveries per day—to accept off-peak deliveries. This is made easier by the fact that the vast majority of large traffic generators have central delivery stations that could receive off-peak deliveries and deliver them to the end customers during normal hours. Since many of these large traffic generators are home to many different businesses, the marginal costs of the off-peak delivery operation would be minimal.

CONCLUSIONS

The paper has put together, on the basis of four different papers dealing with two different research projects, what seems to be the first comprehensive picture of the potential role, limitations of freight road pricing as a demand management tool in congested urban areas. The analyses, complemented with game theoretic discussions of the interactions between carriers and receivers, conclude that moving trucks to the off-peak hours require comprehensive policies targeting key components of the supply chain (i.e., receivers and carriers).

The paper show, on the basis of what seems to be conclusive evidence, that a request from receivers asking carriers to do off-peak deliveries is likely to have an impact across the entire carrier industry; while road pricing only impacts, and rather mildly, specific segments (i.e., carriers transporting petroleum/coal, wood/lumber, food and textiles/clothing). This suggests that the most efficient way to induce a shift of truck traffic towards the off-peak hours is to provide financial incentives to the receivers. In all likelihood, once sufficient numbers of receivers are willing to accept off-peak deliveries, the carriers will follow suit. The paper also discusses economic results that show that receivers, particularly those receiving wood/lumber, alcohol, paper, medical supplies, food, printed materials and metal, are sensitive to tax deductions for a worker assigned to do off-peak delivery work.

In terms of the practicality of these comprehensive policies, the paper discusses the hypothetical example of a $5 toll surcharge to trucks traveling thru the PANYNJ facilities in NYC that would generate approximately $40 million/year (including some demand contraction). These revenues could be used to fund a variety of off-peak delivery programs. Two of the ideas discussed include the provision of incentives to large traffic generators (e.g., Grand Central Terminal, colleges, government offices); and tax incentives to restaurants in Manhattan willing to accept off-peak deliveries. It is estimated that 20% of the restaurants would accept the offer, leading to a reduction of 1.3 million truck trips/year in Manhattan at a cost of $13 million/year.

The paper highlights and rebukes a number of myths related to freight road pricing in urban areas. Separating myth from truth and identifying the possible is a necessary condition to achieve the sound policy objective of moving towards a more balanced use of the existing transportation capacity.

ACKNOWLEDGEMENTS

The analyses in this paper greatly benefited from the collective work of the individuals that co-authored the papers and reports on which the paper is partially based. Among them, the work of Qian Wang, Ning Xu, Noel Pérez, Brenda Cruz, Michael Silas, John Polimeni, Mecit Cetin, Kaan Ozbay, and Shuwen Xia deserves specific mention. The author acknowledges and appreciates the support provided by the Federal Highway Administration’s Value Pricing Program, the New York State Department of Transportation, and the Port Authority of New York and New Jersey. Their staff generously contributed their expertise and insight, without which this paper would not have been possible; though the shortcomings of the paper remain the sole responsibility of the author.

REFERENCES

Abdelwahab, W.M. and M.A. Sargious (1991) "A Simultaneous Decision-Making Approach to Model the Demand for Freight Transportation" Canadian Journal of Civil Engineering, Vol (18) 3, pp. 515-520.

Abdelwahab, W.M. (1998) "Elasticities of Mode Choice Probabilities and Market Elasticities of Demand: Evidence from a Simultaneous Mode Choice/Shipment Size Freight Transport Models" Transportation Research. Part E: Logistics & Transp Review Vol. 34(4) pp 257-266

Chiang, Y. and P.O. Roberts, and M. Ben Akiva (1980) "Development of a Policy Sensitive Model for Forecasting Freight Demand," Center for Transportation Studies, Cambridge, Massachusetts, Report CTS91-1.

Holguín-Veras, J., (2002) "Revealed Preference Analysis of the Commercial Vehicle Choice Process," Journal of Transportation Engineering, Vol. 128, No. 4, American Society of Civil Engineers, July/August pp. 336-346

Holguín-Veras, J. and E. Thorson (2000) "General Patterns of Freight Movements in the NYMTC Region" report prepared for the New York Metropolitan Transportation Council.

Holguín-Veras, J., and G. Patil (2005) "Observed Trip Chain Behavior of Commercial Vehicles" Journal of the Transportation Research Record No. 1906, Transportation Research Board of the National Academies, Washington, D.C., pp. 74-80.

Holguín-Veras, J., J. Polimeni, B.Cruz, N. Xu, G. List, J. Nordstrom and J. Haddock (2005a) "Off-Peak Freight Deliveries: Challenges and Stakeholders Perceptions" Journal of the Transportation Research Record No. 1906, Transportation Research Board of the National Academies, Washington, D.C., pp. 42-48.

Holguín-Veras, J., Q. Wang, N. Xu, K. Ozbay, M. Cetin and J. Polimeni (2005b). 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 (In press)

Holguín-Veras, Myth (2005c) "A Comparative Analysis of U.S. Toll Policy" Transportation Research Part A (In press)

Holguín-Veras, J., N. Pérez, B. Cruz and J. Polimeni (2005d) "On the Effectiveness of Financial Incentives to Off Peak Deliveries to Manhattan Restaurants" submitted to Journal of the Transportation Research Record

McFadden, D., C. Winston and A. Boersch-Supan (1986) "Joint Estimation of Freight Transportation Decisions Under Non-random Sampling," Analytical Studies in Transport Economics, edited by A. Daugherty (Cambridge University Press).

Samuelson, R.D. (1977) "Modeling the Freight Rate Structure." Report No. C.T.S., Center for Transportation Studies, Massachusetts Institute of Technology, Cambridge MA.