THE PORT AUTHORITY OF NEW YORK AND NEW JERSEY ROAD PRICING INITIATIVE: USER IMPACTS

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Abstract

The Port Authority of New York and New Jersey (PANYNJ) implemented a time of day pricing initiative in March 2001. This initiative provides a discount on off-peak tolls on its facilities. Peak toll rates are effective on weekdays form 6-9 AM and 4-7 PM, as well as on weekends from 12 Noon to 8 PM. Approximately 125 million vehicles and 62 million interstate bus passengers use the PANYNJ crossings annually. This is, by far, the largest application of road pricing in the United States.

Following the implementation of the new pricing structure, the Federal Highway Administration decided to sponsor a multi year research project aimed at studying the behavioural impacts produced by time of day pricing. The research project focuses on three main areas: user impacts, systemwide impacts and institutional analyses. In this paper, the authors describe the key findings pertaining to the user impacts produced by the time of day pricing initiative. The paper discusses focus both impacts on passenger and commercial traffic.

1. INTRODUCTION

The concept of road pricing has been gaining support both in the United States, Europe and the Asian countries. The recent London congestion pricing scheme is the latest and one of the most visible implementations. Although the basic fundamentals of road pricing have been known since the 1950s, after Vickrey (1961, 1969) first formulated them, the technologies necessary to implement it did not exist at that time. Over the ensuing decades, these pricing concepts have come to be used by many other industries: electric utility companies charge more in peak periods, restaurants offer "early bird" specials, and commuter rails have long been offering peak and off-peak fares, though road pricing is still only applied to a handful of cases. Proponents argue that road pricing is the key to managing congestion in a world where experience shows that building new capacity does not solve congestion problems. Detractors point to privacy issues, fare structures that impact low income individuals, and the double taxation perception as reasons why road pricing should not be

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considered. In spite of this debate, there are signs that indicate an increasing interest in road pricing as both a revenue generation and a demand management mechanism.

On January 25, 2001, the PANYNJ approved a time of day pricing initiative on its facilities with tolls that depend on time of travel (peak hours, off-peak hours and overnight) and the payment technology used (cash, electronic toll collection). It entered into effect on March 25, 2001. A unique feature of the system is that the toll discounts (see Table 1) are only available to users of the electronic toll collection system (E-ZPass). The PANYNJ saw the plan as a mechanism to help finance its capital budget, and as a means for reducing congestion, increasing the use of mass transit and E-ZPass, and facilitating commercial traffic management. Approximately 125 million vehicles and 62 million interstate bus passengers use the PANYNJ crossings annually (see Figure 1). This is, by far, the largest application of road pricing in the United States.

Figure 1: PANYNJ facilities

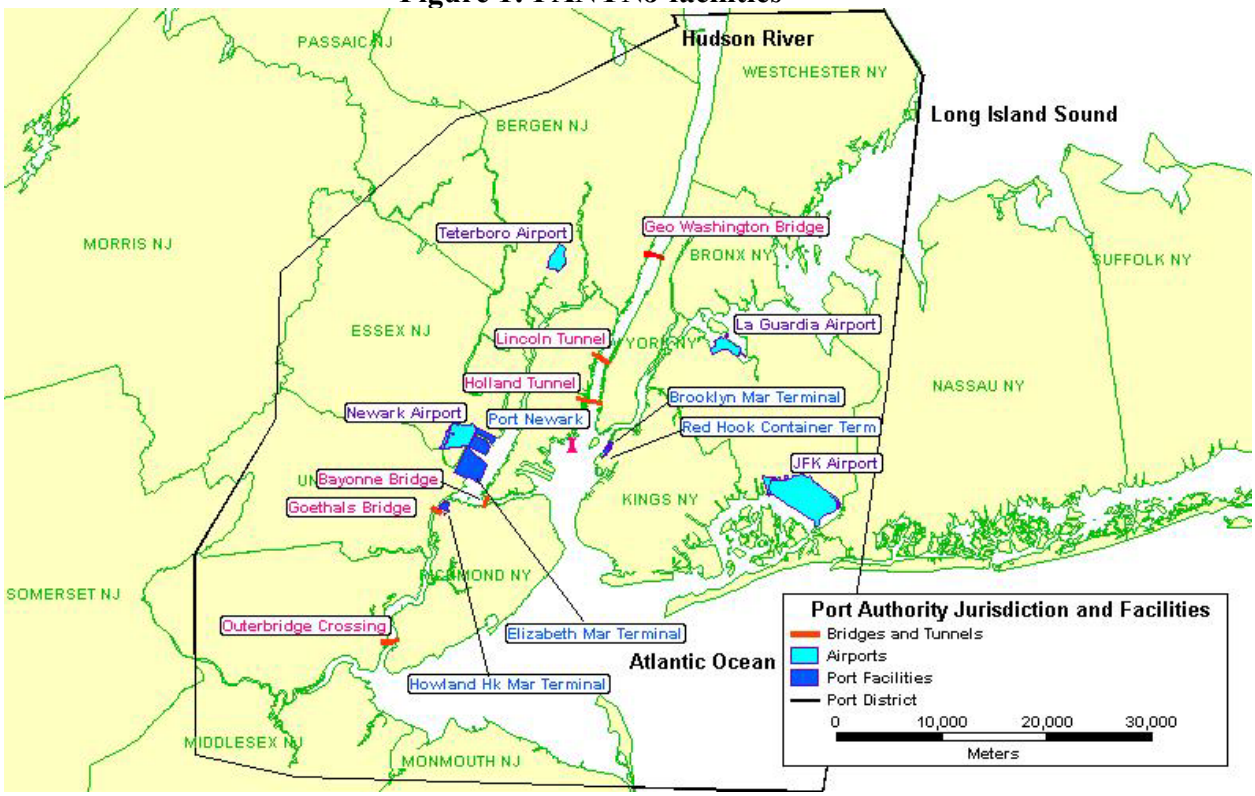

Table 1 E-ZPass toll rates after the Time of Day Pricing Initiative

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

The research project discussed in this paper was sponsored by the Federal Highway Administration's Value Pricing Program to conduct a comprehensive assessment of the impacts of the PANYNJ time of day pricing initiative on user behaviour and traffic patterns. In this context, two surveys were done to capture the behavioural changes of two major

groups of contributors to traffic of PANYNJ facilities, i.e., passengers and carriers. This paper presents the key findings from the descriptive analysis of the two surveys.

The remainder of the paper is organized as follows. Section 2 briefly overviews the survey methodology used and data collected. Section 3 summarizes the key findings from both the passenger survey and the commercial survey. This paper ends with conclusions.

2. THE SURVEY DATA

The passenger survey and the carrier survey were conducted by computer aided telephone interviews (CATI) from June to July and November to December 2004, respectively. The sample characteristics are summarized in Table 2.

Table 2 PANYNJ survey characteristics

Characteristics	PANYNJ passenger survey	PANYNJ carrier survey
Target population	Travelers/Carriers that have or had used the six PANYNJ toll facilities on regular basis (at least once per week) during the past three years	
Areas covered	New Jersey and Staten Island	New Jersey and New York
Sample size	505 passengers	200 carriers
Sampling method	Simple random, random digit dial	Stratified random based on SIC codes

The passenger survey is comprised of 505 complete observations. Among them, 467 respondents (92.5%) are current regular users, i.e., travellers who have driven through the PANYNJ toll facilities on regular basis (at least once per week); 38 respondents (7.5%) are former regular users who drove through the PANYNJ toll facilities on a regular basis before but that now travel regularly by public transportation. Cost considerations suggested collecting the sample from those areas that concentrate the majority of users. As a result, 392 respondents (77.6%) reside in New Jersey while 113 respondents are in New York, specifically in Staten Island (22.4%). The small sample from Staten Island users was included because it was assumed they exhibit a different behaviour because: (1) by virtue of living in an island, their dependence on car and toll bridges is stronger than other local residents; and (2) they enjoy a frequent usage discount plan in which they pay a lower rate ($2.50 per car trip) than the amount New Jersey users are currently paying ($4.00, $5.00 or $6.00 depending on time of day and payment technology).

The carrier survey collected 200 observations from a sample drawn from the Dun and Bradstreet (DNB) database. Of those surveyed, 182 companies (91.0%) are current regular users of the toll facilities, and 18 companies (9.0%) are former regular users (regular users before but sporadic users or nonusers now). Due to the cost constraint, only carriers from New Jersey State and New York State were sampled. 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. From the view point of carrier type, there are 97 for-hire carriers (48.5%) (those that provide services to the open market) and 103 private carriers (51.5%) (those that provide transportation service to a parent or a related company), which is consistent with national statistics.

The two samples collected were expanded so that they represent the behaviour of the entire set of trips made by the interviewed passengers and carriers. This was accomplished by

using the trip frequencies reported by the passengers and carriers as expansion factors for the individual observations. Therefore, the following key findings are based on the usage of toll facilities instead of the individual responses.

3. KEY FINDINGS

Different questionnaires were designed for the passenger survey and carrier surveys to assess their behavioural patterns before and after the time of day pricing initiative. The passenger survey dealt with five main topics for the purposes of descriptive analysis: (1) demographics, (2) impacts of 2001 the time of day pricing initiative, (3) characteristics of the most recent car trips for current regular users; (4) characteristics of the most recent transit trips for former regular users; (5) awareness and usage of E-ZPass. The carrier survey is mainly composed of: (1) company attributes, (2) current operations and travel flexibility, (3) awareness and usage of E-ZPass, and (4) behavioural changes due to the time of day pricing initiative. Stated preference scenarios were conducted to gather data for behavioural modelling. The key findings for both surveys are described next.

3.1 Passenger Survey

Passenger cars are the most significant component of the traffic through the PANYNJ toll facilities. This section summarizes the key findings in terms of the characteristics of the interviewed passengers, the impact of the time of day pricing initiative on their behaviour, their trip attributes, and their awareness of toll discounts.

Demographics

Questions in the demographics section captured the socio-economic profile of the respondents in terms of both individual and household characteristics. The data indicates that the typical respondent is a middle-age white man with above average education level and household income: the average age of respondents is 45.2 years old; 63.5% are white; 58.5% are males; 79.4% received have college or higher education degrees; and have household incomes higher than the State median ($95,178 vs. $55,932 in New Jersey and $80,944 vs. $58,667 in Staten Island) (U. S. Census Bureau 2004). These results are not surprising because experience shows that the population segment most likely to participate in telephone surveys is the group of middle aged white males with above average education level and household income. However, the lack of recent data on the demographics of actual PANYNJ users (as opposed to demographics of New Jersey and New York residents) prevented the use of expansion factors to correct potential biases in the survey.

In addition to household income, the passenger survey gathered data about household structure and car ownership, among others. As shown in Table 3, these households captured in the survey have relatively small families with 2.5 adults and 1.1 children on average, and the average licensed drivers in household is 2.3. Respondents from New Jersey and Staten Island share similar distributions of household structure. More specifically, the dominant group of households is the one with 2 adults which account for almost half of the entire sample (48.6%). The number of licensed drivers in household follows the similar distribution as the number of adults. The most significant group (50.5%) are these that have 2 licensed drivers.

Table 3 Household structure

Household Structure	New Jersey	Staten Island	Entire Sample
Adults in household (Average)	**2.6 adults**	**2.5 adults**	**2.5 adults**
1	20.0%	19.5%	19.9%
2	49.8%	44.3%	48.6%
3+	26.0%	36.1%	28.4%
Do not know/Refused	4.1%	0.1%	3.2%
Licensed drivers in household (Average)	**2.3 drivers**	**2.1 drivers**	**2.3 drivers**
1	22.4%	28.3%	24.4%
2	51.9%	40.2%	50.5%
3+	22.3%	31.5%	25.1%
Do not know/Refused	3.4%	0.0%	2.6%
Children in household (Average)	**1.2 children**	**0.8 children**	**1.1 children**
0	53.1%	55.6%	53.7%
1	19.1%	19.4%	19.2%
2	12.6%	16.6%	13.5%
3+	11.1%	8.3%	10.4%
Do not know/Refused	4.1%	0.1%	3.2%

Table 4 summarizes the distribution of household car ownership in the sample. The average number of cars in household is 2.3. One obvious result is that car ownership is highly correlated with the number of licensed drivers in the household, with nearly 80% of the sample households having at least as many cars as licensed drivers.

Table 4 Household car ownership

Car Ownership	New York	Staten Island	Entire Sample
Number of cars in household (Average)	**2.3 cars**	**2.3 cars**	**2.3 cars**
0	3.7%	5.5%	4.1%
1	26.3%	24.8%	25.9%
2	42.3%	34.2%	40.4%
3+	23.7%	33.1%	25.9%
Do not know/Refused	4.0%	2.5%	3.7%
Among the respondents reporting car ownership:			
Fewer cars than licensed drivers	23.2%	18.5%	22.1%
Cars >= licensed drivers	76.8%	81.5%	77.9%

The fact that most of the respondents reported having high household income and car ownership, hints that tolls may not have a significant influence in changing their travel patterns because tolls are likely to represent a relatively small portion of transportation costs.

The Respondents' Most Recent Trip

The passenger survey collected data about the characteristics of current and former regular users' most recent trips. It was found that the majority of their trips were work related trips, i.e., commuting to or travelling for work. Current regular users reported that 61.5% of their most recent car trips were made for work purposes, either commuting to work (46.3%) or

travelling for job (15.2%). Meanwhile, work related trips account for 83.8% of the most recent transit trips made by former regular users.

The survey also asked their time and day of travel. For both most recent car trips and transit trips, the vast majority were made during weekdays: 77.5% of the most recent car trips and 93.8% of the most recent transit trips. Peak-hour trips were found the dominant trip group. Using the toll schedule from PANYNJ (peak hours: weekdays 6-9 AM and 4-7 PM, weekends noon-8 PM), it was found that approximately 54% of current regular users drove through toll booths in the peak period, among which the weekday AM peak trips (33.9%) are the dominant ones, followed by weekday PM peak trips (13.0%) and weekend peak trips (7.1%). For former regular users, approximately 85% of most recent transit trips were made across toll booths during the peak periods. Weekday AM peak trips account for 80.1%, followed by weekend peak trips (3.6%) and weekday PM peak trips (0.7%).

Further analysis on the relationship between trip purpose and time of travel shows that the vast majority of work related trips were made during peak hours. About two thirds of work related car trips (63.4%) were made during peak periods, especially weekday AM peak hours. Most of work related transit trips (91%) were made during peak periods.

The respondents' time of travel flexibility was quantified in terms of both the departure flexibility (how early or late they can depart from the trip origin) and the arrival flexibility (how early or late they can arrive at the destination). Table 5 shows the average flexibility windows. In general, work related trips have less than 20 minute travel flexibility on average, which reflect the difficulties to shift time of travel.

Table 5 shows a number of interesting features. In general, it confirms the asymmetric nature of flexibility because in all cases respondents have more flexibility to arrive and depart earlier than later. It also highlights that the perceived flexibility for work trips is pretty much the same regardless of mode, which may be a consequence of the very good transit service in New York City during the peak hours. For recreation/shopping trips, the flexibility values when using transit are much higher than the values corresponding to the work trips, which may be a consequence of the reduced level of service during the off-peak hours and weekends, where these trips tend to be made. However, when recreation/shopping trips are made by car, the respondents reported less flexibility. This could be explained by the fact that people are more likely to depart or arrive at the "last minute" for their recreational activities and, equally important, that parking may be less of a problem.

Table 5 Travel flexibility (minutes)

Mean (minutes)	Trip Purpose					
	Work related		Recreation/shopping		Others	
	CT (1)	TT (1)	CT	TT	CT	TT
Earlier departure	19.0	17.9	16.4	30.6	16.2	15.6
Later departure	14.7	14.9	13.8	24.1	14.4	15.6
Earlier arrival	20.4	18.3	16.0	32.6	24.2	19.5
Later arrival	12.3	9.1	12.3	23.6	9.7	8.3

Note : (1) CT and TT mean most recent car trips and most recent transit trips separately.

E-ZPass Usage and Awareness of Toll Discounts

Since the toll discounts are available only to E-ZPass users, it is important to assess user awareness of the available toll discounts. In general, respondents reported high usage of E-ZPass but low awareness of toll discounts: 78.3% of respondents said that they currently have E-ZPass tags, though 62.7% knew about some kind of discount, and only 17% knew

about the time of day pricing discount (only 20.8% of E-ZPass users knew about it). Moreover, only 16.7% of E-ZPass users correctly reported the amount of tolls they paid for the most recent trip, while 58.1% of cash users reported tolls correctly. Low awareness of toll discounts, especially the time of day initiative, is bound to constrain the level of penetration of E-ZPass and, ultimately, diminish the ability of the time of day pricing in balancing traffic throughout the day.

Impacts of 2001 the Time of Day Pricing Initiative on Passenger Behaviour

In general terms, users of the PANYNJ facilities tend to be inelastic to tolls. The data indicates that 35 out of 505 individuals (representing 6.9% of individuals and 7.4% of trips) changed their behaviour after the time of day pricing initiative. The majority of the individuals (28 out of 35 individuals) who changed behaviour still travel through the six PANYNJ toll facilities on a regular basis. These respondents account for 5.5% of users and 4.6% of trips. In contrast, the other group of individuals reporting behavioural changes (7 out of 35 individuals) switched to public transportation and reduced their car trips to less than once per week. They account for 1.4% of individuals and 2.7% of trips. It is interesting to note that, when asked a follow up question about the main reason why they switched to transit, only 2 out the 7 individuals mentioned the toll costs. This may suggest that there are other factors, in addition to tolls, that played a role in their mode choice decisions.

Lack/no flexibility and no willingness to change are the two major reasons for people not to change behaviour. People did not change behaviour because *they had no choice or no flexibility to change* (45.5%), or because they believe *they should travel whenever they want to* (32.4%). Other respondents felt that *the toll difference was not enough to justify a change* (8.8%), or *it was paid by their employers* (5.3%), and some said that *they did not use the facilities enough in order to change* (2.4%).

The individuals who changed behaviour because of the time of day pricing tend to:

- Be females: Women account for 57.6% of the individuals who changed behaviour in contrast to only 40.2% of those who did not change behaviour. This may be an indication that women are more sensitive to price changes.
- Be younger than those who did not change: The average age (38.3 years) is about seven years younger than those who did not change (45.2 years).
- Have a relative lower education level than those who did not change: 38.6% of users who changed behaviour have four year college or higher, vs. 56.1% for those who did not change.
- Earn relatively less than those who did not change: the median income is $88,570 per year in contrast to $98,295 per year for those who did not change.
- Have relatively smaller families with less adults but almost the same number of children than those who did not change: The average number of adults in the household for users who changed behaviour is 2.1 while the number is 2.5 for those who did not change. Furthermore, 36.5% of the households of those who changed behaviour have only one adult; in contrast to 22% among those who did not change.
- Adopt multiple combinations of strategies to deal with time of day pricing: Most of the respondents that changed behaviour reported multiple changes, frequently involving three and more, e.g., changes in car trip frequency plus change of transportation mode

plus other reactions. The most important two-dimension combinations include: reducing car trips plus increasing transit trips plus …. (2.5%), increasing transit trips plus increasing (or starting) carpooling plus …. (1.8%), increasing the transit trips plus switching to E-ZPass plus …. (1.2%) as their strategy. A small proportion of people who changed their number in weekdays tended to decrease the trips in peak hours but increase the trips in off-peak hours (1.2%). Also, a group of people decreased their car trips in both weekday peak and off-peak periods (1.0%). It is obvious that this pattern of time of travel switch is more significant during weekdays than during weekends. Other combinations include: decreasing car trips plus switching to carpools plus …. (1.1%), and decreasing car trips during both weekend peak hours and weekend off peak hours plus …. (0.9%). The most frequently cited changes were a: shift towards public transportation (4.2%), reduction in the car trips frequency (3.0%), shift towards carpooling (1.9%), shift towards E-ZPass (1.5%) and a decrease in the number of stops per trip (0.6%).

3.2 Carrier Survey

The carrier survey's objective was to quantify the changes post time of day pricing initiative. The key findings are summarized below.

Company Attributes

The interviewed carriers are categorized into current regular users and former regular users depending on whether they currently dispatch trucks between New York City and New Jersey using the PANYNJ toll facilities on a regular basis, i.e., at least once a week.

Current regular users tend to:

- Provide Less Than Truckload (LTL) or Full Truckload (FTL) services: The majority of current regular users do LTL services (54.1%) or FTL (34.6%). Other services mentioned include intermodal (11.1%), drayage (4.2%), or marine containers (1.0%).
- Operate medium to large fleets: The average fleet size is 53.9 trucks, and the most significant group of current regular users (34.9%) owns more than 50 trucks
- Own more large size trucks (trailers/semi-trailers) than small size trucks (two, three/four axle trucks): Trailers/semi-trailers are the equipment types more frequently owned by current regular users (88% of users), followed by two-axle trucks (55.3%) and then three/four axle trucks (58.7%). Moreover, the average number of trailers/semi-trailers owned by current regular users is 38.0 trucks while the average numbers of two-axle trucks and three/four axle trucks owned are 10.3 trucks and 4.6 trucks separately.
- Work on New Jersey and New York, not venturing far from the Mid-Atlantic region: The majority of shipments for current regular users originate in New Jersey (71.1%) and New York (8.5%). The majority of shipments tend to be originated at the states where these companies are located. Current regular users were found not to venture far from the Mid-Atlantic region. Therefore, the four large states of the Mid-Atlantic region, New York State (74.3%), New Jersey (29%), Pennsylvania (13.3%) and Connecticut (10.2%), represent the major destination of most shipments for current users.

Among current regular users, for-hire carriers and private carriers exhibit some differences in company attributes. In general, private carriers are more likely to focus on LTL services or FTL services rather than intermodal or other services. For-hire carriers tend to be larger

than private carriers (67.3 vs. 31.0 trucks). In terms of fleet composition, private carriers are more likely to own smaller-size trucks (i.e., two/three/four axle trucks), while for-hire carriers tend to own larger truck combinations, i.e., trailers/semi-trailers. For-hire carriers employ more interstate truck drivers and more interstate truck drivers per truck than private carriers, which indicate their predominantly interstate roles.

Former regular users reported different company characteristics than current regular users. The average fleet size for former regular users is 12.9 trucks compared with 44 trucks for current regular users. As a result, they employ less interstate drivers. They also tend to dispatch their trucks within the states where their companies are located.

Current Operations and Travel Flexibility

On average, a typical tour made by current regular users takes about 409 minutes, and they make 6.4 truck trips per day and 13.0 stops per tour. Current regular users carry various types of commodities. The most significant cargo types delivered by these carriers include: household goods/various (25.0%), textiles/clothing (22.4%), food (20.0%), and machinery (14.6%) among others. The average load factor for current regular users is 85.2%. The relatively high values of the load factor suggest the reported values correspond to the values for trucks leaving the home base.

The analysis of the breakdown of trips by time of day indicates that about 69.5% of trips are made during peak hours, 20.0% during day time off-peak hours, and 10.4% during overnight hours. When asked about reasons why trucks travel on this schedule as opposed to other times of day, 61.6% of current regular users said customer requirements dictate schedule, which confirms the key role played by cargoes' receivers in setting the delivery times. Only 3.5% said the toll is cheaper which indicates the minor role of toll cost in determining carriers' time of travel choices.

The data indicate that about three quarters of carriers (74.2%) do not have any time of travel flexibility in terms of arrival flexibility. For those that reported some arrival flexibility (25.8%), the average early arrival flexibility and late arrival flexibility are 37.3 minutes and 48.8 minutes respectively (see Table 6). About 10% of current regular users have flexibility of more than half an hour. The analysis of flexibility indicates that for-hire carriers are more constrained by the schedule and, as a result, have much less flexibility than private carriers. As a result, for-hire carriers are less sensitive to tolls because they have to arrive at the destinations on time.

Table 6 Time of travel flexibility by carrier type (minutes)

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

E-ZPass Usage and Awareness of Toll Discounts

Similar to passengers, the interviewed carriers are dominated by E-ZPass users. 90.3% of current regular users currently use E-ZPass to travel through the PANYNJ toll facilities. However, it seems clear that current regular users are not fully aware of available toll discounts. Only 25.8% knew about off-peak or non-rush hour use discounts. The comparison between E-ZPass and cash users indicates that E-ZPass users seem to have poorer aware-

ness of toll discounts even though they are using E-ZPass. 25.9% of E-ZPass users knew about off-peak or non-rush hour use discount in contrast to 37.9% for cash users.

Impacts of 2001 the Time of Day Pricing Initiative on Carrier Behaviour

The data indicate that 28 carriers (14% of the raw sample) changed behaviour (increasing shipping charges was considered a behaviour change) because of the time of day pricing initiative. This includes 23 current regular users that changed behaviour in different ways though still remained using the PANYNJ facilities (12.6% of current regular users and 11.7% of current truck traffic); and 5 former regular users that cited tolls as the key reason to stop using the facilities. 2 out these 5 carriers reported tolls as the key reason for stopping using the facilities; while the remaining 3 cited toll costs as a contributing factor to the overall high costs that forced them to change their business patterns. Since former regular users were not asked questions about behavioural changes, the key analysis focuses only on current regular users.

In general, the carriers that changed behaviour because of the time of day pricing tend to:

- Focus on full truck load (FTL) service: The vast majority of those carriers that changed behaviour (81.2%) are FTL operators. Conversely, LTL operators (56.9%) were the core of those that did not change operations after the time of day pricing initiative.
- Own smaller fleets than those that did not change: The average fleet size of carriers that changed behaviour (44.5 trucks) is approximately ten trucks smaller than the fleet size of those that did not change (55.1 trucks)
- Employ less interstate truck drivers but more interstate truck drivers per truck: Carriers that changed behaviour hire 30.6 interstate drivers on average while those that did not change have an average of 39.3 drivers. The percentage of the companies that changed behaviour because of the time of day pricing (26.6%) is almost four times higher than the one of those that did not change in the range of 1.0 to 1.5 interstate truck drivers per truck (7.2%) (a ratio larger than one is possible in those cases in which a team of two drivers are assigned to the same truck). The average interstate truck drivers per truck owned by carriers that changed behaviour (0.8 drivers per truck) are 0.1 higher than the one for those that did not change (0.7 drivers per truck), which indicate that interstate truck trips play a significant role in their operations.
- Venture in the areas outside of New Jersey and New York: The distributions of origins and destinations of shipments indicate that the carriers that changed behaviour are more likely to transport shipments originating in areas other than New Jersey and New York and deliver the majority of their shipments to the areas outside the Mid-Atlantic region. A significant proportion of the carriers that changed behaviour have shipments originating in Pennsylvania (23.6%) or Maryland (19.9%), which is much higher than the ones among those that did not change (0.4% and 0.0% respectively). About 71% of these carriers send their cargoes to the areas outside the Mid-Atlantic region (e.g., Massachusetts and Maryland) while only 25.4% of those that did not change behaviour do so.
- Adopt multiple combinations of strategies to deal with time of day pricing: As in the passenger case, carriers employed combinations of strategies to deal with the time of day pricing initiative. These include: *decreasing the truck trips through the toll booths* plus *passing the additional costs generated by the toll changes to their customers* plus …. (6.7% of current regular users), *changing routes* plus *increasing charges* plus ….

(6.1%), *decreasing truck trips* plus *changing routes* plus …. (4.5%), combinations between *switching business to other areas* and *increasing shipment charges* plus …. (2.6%), *decreasing their truck trips through the toll facilities* plus …. (2.6%), or *changing their delivery routes* plus …. (2.6%); and *switching to E-ZPass* and simultaneously either *decreasing truck trips* (2.4%) or *increasing shipment charges* (2.3%). Overall, the changes most frequently cited are: *increasing shipment charges* (9.9%), *reducing truck trips* (6.8%), *changing their routes to avoid toll facilities* (6.9%), *switching to or increasing the usage of E-ZPass* (3.6%). *Changing the time of travel to the off peak hours* was found to be a really minor strategy, only 0.5% of current regular users shifted to off-peak periods because of the time of day pricing.

The survey asked the users that did not change why they did not make any change after time of day pricing. The most significant reason is that they do not have a choice (75.3%). They felt that either *they can not change schedule due to the customers' requirements* (68.9%) or *they must use the quickest route* (6.4%). This indicates that their customers, most probably receivers, control the time of travel decisions. Other reasons include the *travel cost (including tolls) is paid by someone else* (19.8%), *price difference not all that much/can afford it* (2%). A very small proportion of carriers seem to be off-peak users since 0.4% said there was no change in the cost for off-peak travel.

4. CONCLUSION

This research project has outlined a series of conclusions that, though needing further corroboration from behavioural modelling, may be of interest to the road pricing community. The analyses of the passenger data collected suggest that individuals who changed behaviour are more likely to: be female, younger; have a relative lower education level; earn relatively less; and have relatively smaller families with less adults but almost the same number of children than those who did not change.

These individuals adopt combinations of multiple strategies to deal with time of day pricing. Most of the respondents that changed behaviour reported multiple changes, frequently involving three and more, e.g., *changes in car trip frequency* plus *change of transportation mode* plus other reactions. The top three combinations include: *reducing car trips* plus *increasing transit trips* plus …. (2.5%), *increasing transit trips* plus *increasing (or starting) carpooling* plus …. (1.8%), and *increasing the transit trips* plus *switching to E-ZPass* plus …. (1.2%).

The carriers that changed behaviour tended to: focus on full truck load (FTL) service; own smaller fleets than those that did not change; employ less interstate truck drivers but more interstate truck drivers per truck; venture in the areas outside of New Jersey and New York. This suggests that the more elastic industry segment to tolls is the group of relatively smaller FTL operators doing long distance trucking. Among other things, this is the segment that has more alternative routes to their disposal.

As in the passenger case, the carriers employ combinations of s multiple strategies to deal with time of day pricing. The top three most significant ones involve: *decreasing the truck trips through the toll booths* plus *passing the additional costs generated by the toll changes to their customers* plus …. (6.7% of current regular users), *changing routes* plus *increasing charges* plus …. (6.1%), and *decreasing truck trips* plus *changing routes* plus …. (4.5%). The fact that the most frequently cited change is increasing shipment charges to their customers (most likely receivers) suggests that, in order to fully understand the broad impacts

of pricing more research is needed to specifically find out how receivers reacted to the shipment charge increases enacted by the carriers. Only then, the road pricing community would begin to develop a full understanding on the broad impacts of pricing on the behaviour of the commercial sector.

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