Alternative High Occupancy/Toll Lane Pricing Strategies and their Effect on Market Share

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High Occupancy/Toll (HOT) Lanes typically charge a varying to single occupant vehicles (SOVs), with the toll increasing during more congested periods. The toll is usually tied to time of day or to the density of vehicles in the HOT lane. The purpose of raising the toll with congestion is to discourage demand enough to maintain a high level of service (LOS) in the HOT lane. Janson and Levinson (2014) demonstrated that the HOT toll may act as a signal of downstream congestion (in both general purpose (GP) and HOT lanes), causing an increase in demand for the HOT lane, at least at lower prices. This paper builds off that research and explores alternative HOT lane pricing strategies, including the use of GP density as a factor in price to more accurately reflect the value of the HOT lane. In addition, the paper explores the potential effect these strategies would have on the HOT lane vehicle share through a partial equilibrium analysis. This analysis demonstrates the change in demand elasticity with price, showing the point at which drivers switch from a positive to negative elasticity.

Total Words = 4423 + 250*12(6 Figures & 6 Tables) = 7423

1 Introduction

High Occupancy/Toll (HOT) lanes charge a toll to single occupant vehicles (SOVs) for several reasons. The toll serves to raise revenue to cover operating costs and to regulate the demand of SOVs. HOT lanes around the country use different methods for determining the toll, however, all methods raise the toll price during more congested periods. The theory is, a higher toll price discourages demand and is used to maintain a high level of service (LOS) in the HOT lane(s). Janson and Levinson (2014) showed, however, that a higher price may act as a signal of downstream congestion (in both the general purpose (GP) and HOT lanes), causing demand for the HOT lane to increase to a point.

This paper explores current HOT pricing strategies and proposes some alternatives. These alternative strategies are tested using a partial equilibrium analysis. This analysis uses a calibrated HOT lane choice model to determine the HOT lane share at various prices and determine demand elasticity to price.

2 Pricing on HOT Lanes

Table 1 summarizes the tolling strategies of various HOT lanes around the United States. Several HOT lane systems base the toll on time of day, while others are dependent on HOT density or speed. Details of Minneapolis' MnPASS lanes' pricing system are outlined in the following section.

Table 1: HOT Lane Tolling Strategies

City	Highway	System Open Date	Length (miles)	Toll Dependency
Atlanta[7]	I-85	2011	16	HOT Density
Denver[4]	I-25	2006	7	Time of Day
Houston[9]	I-10	2009	12	Time of Day
Miami[6]	I-95	2008, 2014	8, 13 (total)	HOT Density
Minneapolis[10]	I-394	2005	11	HOT Density
Orange County[1]	SR 91	2003	10	Time of Day
San Diego[5]	I-15	1998	12	HOT Density
Seattle[13]	SR 167	2008	9	HOT Speed
Washington, D.C. [12]	I-495	2012	14	HOT Density

3 MnPASS Current Operation

The MnPASS lanes in Minneapolis operate during the morning and afternoon peak periods. With several exceptions, the general operating hours are from 6:00-10:00 and 14:00-19:00. Prices during operation times range from a minimum of $0.25 to a maximum $8.00. I-394 and I-35W are each divided into multiple sections with prices posted for use of each segment. The maximum price

applies to use of each section individually, as well as use of all sections.

Prices are adjusted every three minutes based on density levels measured in the MnPASS lanes only. Traffic levels in the general purpose (GP) lanes do not directly influence price. Loop detector counts are taken every 30 seconds and used to calculate the density in the MnPASS lanes plazas along the corridor. Density measurements are averaged over the last 6 minute period in order to smooth out fluctuations and based only on downstream congestion. Price is dictated by the magnitude of density as well as the change in density over the previous 6 minutes. A rise in density creates an increase in price. Table 2 displays the pricing plan, which regulates the price based on density level. Minimums and maximums for a given LOS must be maintained. The table also indicates the changes in price caused by a change in density.

Table 2: Pricing Plan for Normal Operation of MnPASS Lanes (both I-35W and I-394)

Level of Service	Min K	Max K	Min Rate ($)	Default Rate ($)	Max Rate ($)	
A	0	11	0.25	0.25	0.50	
B	12	18	0.50	0.50	1.50	
C	19	31	1.50	1.50	2.50	
D	32	42	2.50	3.00	3.50	
E	43	49	3.50	5.00	5.00	
F	50	50	5.00	8.00	8.00	
Change in Price from Density Change						
K	Δ 1	Δ 2	Δ 3	Δ 4	Δ 5	Δ 6
0-18	0.25	0.25	0.25	0.25	0.25	0.25
19+	0.25	0.50	0.75	1.00	1.25	1.50

Density in veh/mi/ln; Prices in $

4 Alternative Pricing Strategies

The following pricing strategies are proposed alternatives to the current system used on the MnPASS HOT lanes. The continuous function is similar to the current pricing algorithm in that it relies strictly on HOT density for determining price, however, instead of relying on a series of tables, price is determined from a simple mathematical equation. The three other value pricing strategies incorporate GP density and use the difference in density between the HOT and GP lanes to determine price. Details of the pricing strategies are outlined below.

In all cases, the prices are confined to several contraints to match the existing pricing algorithm. The minimum price is $0.25, the maximum $8.00 and all prices are rounded to the nearest $0.25. The following equation represents the contraints which are applied after the unconstrained price is determined.

$$P_{constrained} = Rnd(Min(Max(P_{unconstrained}, 0.25), 8.00), 0.25) \quad (1)$$

$P_{unconstrained}$ may be defined several ways, as discussed below.

4.1 Continuous Function

Prices using this function are determined by:

$$P_{continuous} = \alpha * K_{HOT}^{\beta} \tag{2}$$

where P represents the price in USD and K the density in vehicles/mile/lane.

K_{HOT} is found using the same method as the current algorithm (maximum downstream density averaged over last 6 minutes). α and β are constants which can be adjusted to achieve the desired curve.

4.2 Unweighted Value Pricing

While the current pricing algorithm only evaluates the density in the HOT lane, this pricing strategy would compute price based on the difference in density between the GP and HOT lanes. The difference in density between the lane groups is correlated with a difference in time savings and therefore, the value provided by the HOT lane. Implementation of this pricing scheme (and subsequent strategies), will require the integration of GP density as a factor in determining price. GP density is averaged among parallel detectors. The maximum downstream GP density is then used to determine price, along with the maximum downstream HOT density.

$$P_{Value_{unweighted}} = \gamma * [K_{GP} - K_{HOT}] \tag{3}$$

4.3 $HOT_{weighted}$ Value Pricing

Differences in density between GP and HOT lanes do not correlate directly to travel speeds. Rather, there is a correlation with the magnitude of densities. For example, little speed difference exists between 10 and 20 vehicles/mi/ln (approximately 6 and 12 veh/km/ln), both likely experience free flow speeds. However, a greater speed difference exists at higher densities (between 40 and 50 veh/mi/ln (approximately 25 and 31 veh/km/ln)). Therefore, it makes more sense to weight the density difference between the GP and HOT, based on the magnitude of density. This function weights the difference based on the magnitude of the HOT lane density. Similarly to the current algorithm, price will increase proportionally with HOT density.

$$P_{ValueHOT_{weighted}} = \delta * [K_{GP} - K_{HOT}] * K_{HOT} \tag{4}$$

4.4 $GP_{weighted}$ Value Pricing

This pricing strategy is weighted based on GP density instead of HOT density. If $K_{GP}$is much greater than K_{HOT} and K_{HOT} is very low, then the HOT weighted value pricing strategy would yield a low price even though there would be a significant value in using the HOT lane. By weighting based on K_{GP}, this strategy ties price more directly to the GP lane congestion and the actual time savings gained by using the HOT lane.

$$P_{ValueGP_{weighted}} = \sigma * [K_{GP} - K_{HOT}] * K_{GP} \tag{5}$$

5 Partial Equilibrium Analysis

The partial equilibrium analysis involves using a fixed demand of SOVs with predefined commute times and locations to calibrate a lane choice model and eventually test alternative pricing strategies. The SOVs are equipped with transponders and can decide whether to use the MnPASS or GP lanes based on the toll and their expected travel time and reliability. The following sections outline the process.

6 Lane Choice Model

This HOT lane choice model extends work done by Carlos Carrion (Carrion, 2010). The binomial logit model determines the probability of a vehicle using the HOT lane based on several independent variables. These variables include estimated travel times and travel time variability for both the HOT lane and the GP lanes, as well as the posted toll price. The lane choice model applies only to SOVs equipped with transponders. SOVs not equipped with transponders are not allowed to use the MnPASS lanes. A separate subscription choice model was developed to determine which vehicles are equipped with transponders. Details of this model are outlined in Owen et al. (2013).

6.1 Model Coefficients

Utility from Carrion (2010) is described as:

$$U = f(T, V, P, A)$$

where:

T: Expected Travel Time The utility decreases with an increase in expected travel time, decreasing the probability of using the given lane type. Expected travel time is measured in minutes.

V: Travel Time Variability Travel time variability in this model is defined as the 90th percentile - 50th percentile to correspond with Carrion (2010). This value is calculated separately for the HOT lane and GP lanes. Like expected travel time, an increase in variability decreases the probability of using that lane. Travel time variability is measured in minutes.

P: Expected Toll Price The expected toll variable is based on the dynamic message sign posted price. The price corresponds to a user's entry and exit points. This model assumes all drivers will exit in downtown Minneapolis. Therefore, the expected toll will vary only by entry point. Toll prices are in USD. The negative sign indicates a dissuasion from higher tolls, assuming all other factors remain constant.

A: Alternative Specific Constant In this model, the ASC was defaulted to zero and adjusted if necessary in the calibration.

7 Calibration of Lane Choice Model

While the model was previously calibrated in (Carrion, 2010), the calibration relied on a very small sample size of vehicles and was therefore, recalibrated using the following methodology.

The lane choice model was calibrated by matching a set of simulated vehicles' HOT lane decisions to historical data. The list of vehicles was generated from trip tables provided by the Metropolitan Council. All vehicles are SOVs traveling eastbound to downtown Minneapolis on I-394 between 6:00-10:00 AM. Each vehicle has an entrance ramp and time of entry into the system. The subscription choice model from Owen et al. (2013) is first applied to filter non-transponder owning SOVs. Each vehicle experiences various travel times based on the entrance ramp and time of entry. These travel times are the basis of the expected travel time and travel time reliability parameters of the lane choice model. Details of the calibration steps are outlined in the following sections.

The lane choice model coefficients are adjusted using a grid search technique. Default values for the coefficients were taken from Carrion (2010), with the exception of the alternative specific constant (ASC) which was set to zero. The grid search approach involves adjusting each of the coefficients separately, while keeping all others constant. The first coefficient is altered until the model achieves its best fit to the calibration target. This coefficient is then kept constant and the second coefficient is adjusted and so on until the fit can no longer be improved.

In this model, the ratio of expected travel time to travel time variability was kept constant and the ASC was defaulted to zero. The travel time coefficients were adjusted first, followed by the toll coefficient and ASC (if necessary). The ratio of expected travel time to travel time variability was kept constant due to the extensive literature research outlined in from Carrion and Levinson (2012) in determining this value.

7.1 Travel History

Each vehicle builds a travel time history by experiencing MnPASS travel times along the corridor based on their entrance ramp and time of entry. All travel is along I-394 Eastbound to downtown Minneapolis. The travel times are calculated using loop detector data from each Wednesday of 2012 (except July 4 and December 26). This travel history determines a vehicle's expected travel time (mean of travel history) and travel time variability (90th percentile minus 50th percentile.

7.2 Calibration Target

In order to calibrate the lane choice model, it is necessary to determine the probability that a transponder owning SOV will use the MnPASS lane.

Using Bayes' theorem:

$$Pr(L|R) = Pr(R|L) * Pr(L)/Pr(R) \tag{6}$$

$Pr(R)$ is the probability of radio transponder ownership (from subscription choice model). $Pr(L)$ represents the probability of using the HOT lane among all SOVs. $Pr(R|L)$ is the probability of owning a transponder given use of the HOT lane. Since only SOVs are being considered, $Pr(R|L)$ is 1 (or 100%) assuming no illegal use of the HOT lane.

Pr(L) was calculated by finding the number of SOVs using the MnPASS lane and dividing by total number of vehicles using the corridor during the same time period. Total vehicle counts were gathered from loop detector data. The number of HOVs using the GP lanes is assumed to be zero. Counts of SOVs using the MnPASS lane come from transponder data which shows entry and exit plazas and entry time, along with paid toll price. By comparing the counts throughout morning peak period with the GP loop detector data, Pr(L) can be determined.

Pr(R) was calculated by correlating the subscription choice model in Owen et al. (2013) with subscription data for each transportation analysis zone (TAZ) along the corridor. Each vehicle's entrance ramp can be probabilistically correlated to surrounding TAZs. By then applying the subscription choice model to the total set of SOVs, a subset of transponder equipped SOVs is formed. This is likely a lower bound of transponder usage, since transponder owners in a TAZ are more likely to use MnPASS (or MnPASS corridor users are more likely to own a transponder) than a random traveler from a TAZ.

7.3 Calibration Day

In previous research conducted by the Minnesota Traffic Observatory (MTO), trip generation models and traffic simulations were calibrated to November 29, 2011. This day was selected because it was an average day with no weather or crash related problems along the MnPASS corridors. Due

to the connection of this research to the calibrated simulation used in the MTO, this calendar day was selected for calibration of the lane choice model.

The $Pr(L)$ value from 11/29/2011 and $Pr(R)$, result in:

$$Pr(L|R) = (100\%) * (11.8\%)/(17.3\%) = 68.1\% \tag{7}$$

7.4 Price-Time Savings and Price-Reliability Models

Although the MnPASS toll price fluctuates based on HOT density, there is a direct correlation between the toll and the time savings the MnPASS lanes provide over the GP lanes. The higher the toll, the greater the time savings. This correlation is observed by users and explains the positive demand elasticity to price results in Janson and Levinson (2014).

Using average toll prices and time savings data from 2012, a log relationship was fit. The bimodal relationship of the data meant two log functions were fit, one for congestion onset and one for the offset.

The relationship between price and time savings during congestion onset and offset are displayed in Table 3. The corresponding curves are displayed in Figure 1.

The increased travel time reliability of the MnPASS lanes is also proportional to the toll price. Again, two log functions were fit to the congestion onset and offset data.

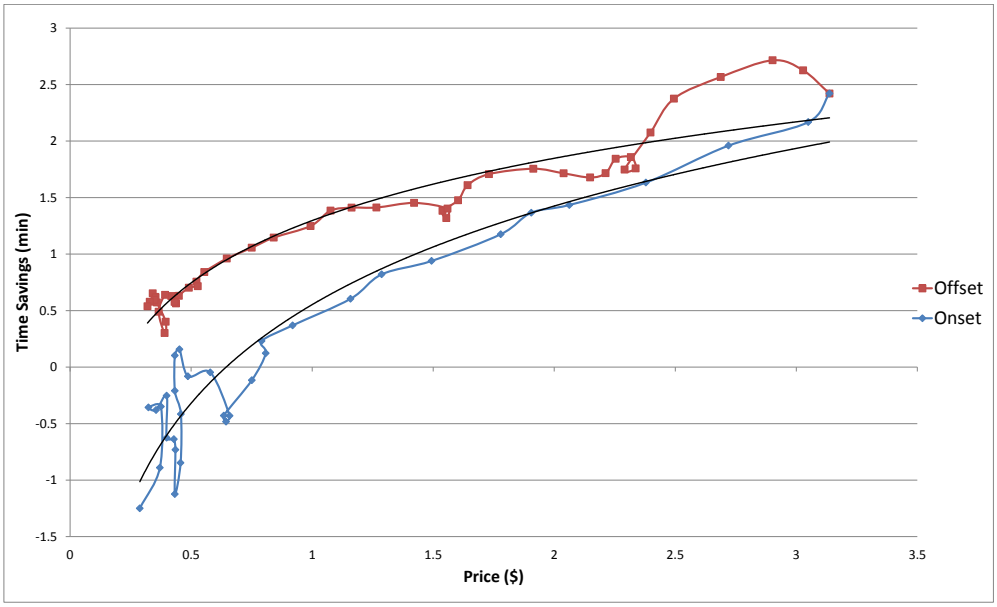
The relationship between price and time savings during congestion onset and offset are displayed in Table 3. The corresponding curves are displayed in Figure 2.

Table 3: Price-Time Savings and Price-Reliability Regression Results

	Time Savings vs Price		Time Variance Difference vs Price	
Variable	Onset	Offset	Onset	Offset
Intercept	0.5527(0.05972)***	1.2965(0.02912)***	0.9566(0.03867)***	1.6636(0.01664)***
$log(P)$	1.2587(0.07732)***	0.7953(0.03743)***	1.1413(0.05006)***	0.926(0.02139)***
n	40	40	40	40
r^2	0.8923	0.913	0.942	0.9657

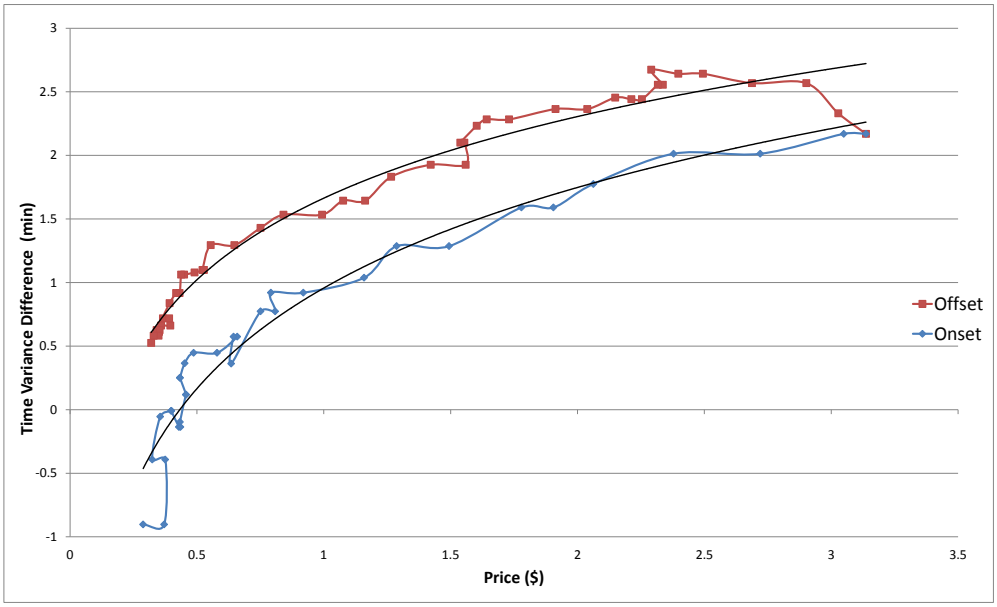
(Standard error in parentheses)
*Significance * 0.05, ** 0.01, *** 0.001*
Time Savings and Time Variance Difference in minutes are the dependent variables, price in USD is the independent variable

Figure 1: Price-Time Savings Log Model



$\Delta T_{onset} = 1.2587ln(P) + 0.5527$ *(r^2=0.8923)*
$\Delta T_{offset} = 0.7953ln(P) + 1.2965$ *(r^2 = 0.913)*
where ΔT is travel time savings in minutes and P is price in USD

Figure 2: Price-Reliability Model

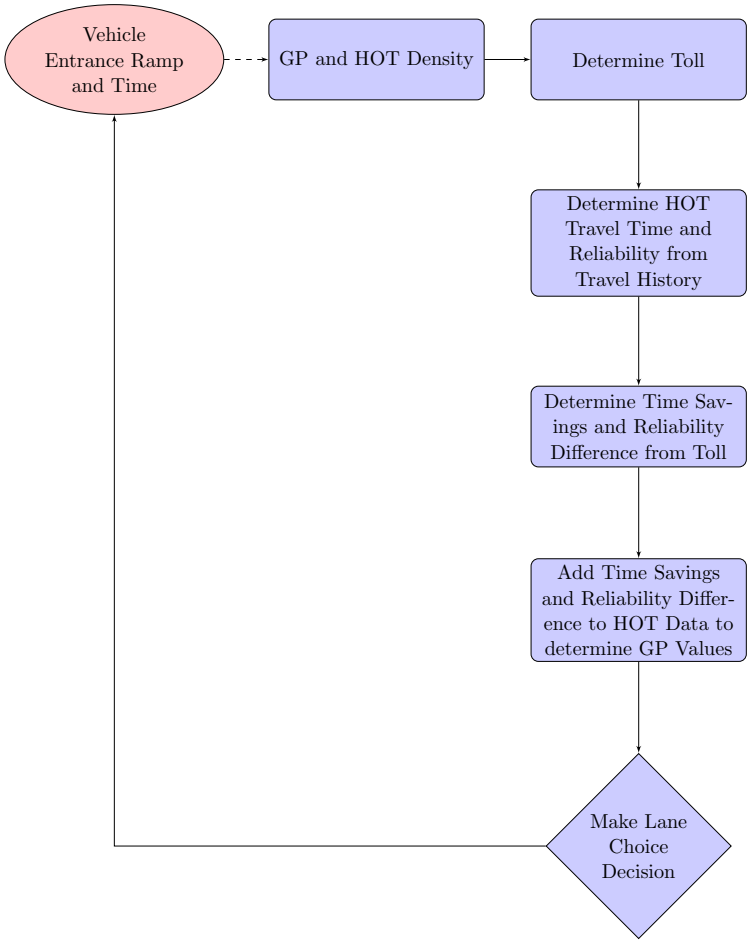


$\Delta V_{onset} = 1.1413ln(P) + 0.9566$ *(r^2 = 0.942)*
$\Delta V_{offset} = 0.926ln(P) + 1.6636$ *(r^2 = 0.9657)*
where ΔV is time variance difference in minutes and P is price in USD

7.5 Calibration Process

The following flowchart displays the lane choice model calibration cycle using the grid search technique. Once lane choice decisions for all vehicles have been completed, the percentage of vehicles using the HOT lane ($Pr(L|R)$) is compared to the calibration target of 68.1%. The model coefficients are then adjusted to increase or decrease $Pr(L|R)$ and the process is repeated until the optimal coefficients are found.

Figure 3: Calibration Cycle



7.6 Resulting Coefficients

The lane choice parameters were for both congestion onset and offset. The resulting values are found in Table 4 below.

Table 4: Lane Choice Model Parameters for Calibration

Parameter	Carrion(2010)	Onset	Offset
Expected Travel Time	-0.672	-7.27	-10.7
Travel Time Variability	-0.228	-2.47	-3.63
HOT Lane Toll	-6.94	-6.94	-6.94
Alternative Specific Constant	-2.23	0	0

8 Testing of the Alternative Pricing Strategies

The calibrated HOT lane choice model was used to test the behavior of the alternative pricing strategies and how changing prices affect $Pr(L|R)$, which is the share of transponder owning SOVs which use the MnPASS lane.

$$Pr(L|R) = \frac{\text{\# of transponder owning SOVs using the MnPASS lane(s)}}{\text{Total \# of transponder SOVs using the corridor (all lanes)}} = Pr(L|R) \qquad (8)$$

Each pricing strategies' coefficients were incrementally adjusted and the process rerun to determine the resulting $Pr(L|R)$. The average price and $Pr(L|R)$ were recorded for each iteration. The results were graphed and fit for each pricing strategy (congestion onset and offset). Table 5 displays the regression results from fitting one pricing strategy using a first, second, third and fourth order polynomial function. The fourth degree polynomial functions for each scenario are displayed in Table 6 and graphs of the Continuous Function (congestion onset and offset) are displayed in Figure 4.

Table 5: Continuous Pricing Function Onset Regression Results

Variable	Model 1 (1st order)	Model 2 (2nd order)	Model 3 (3rd order)	Model 4 (4th order)
Intercept	21.46(5.321)***	-0.9280(3.140)	-15.297(1.997)***	-25.884(0.9949)***
P	1.017(1.291)	35.019(2.892)***	71.931(3.546)***	108.91(2.670)***
P^2	-	-4.5576(0.3788)***	-17.218(1.129)***	-40.396(1.516)***
P^3	-	-	1.0781(0.09485)***	5.7446(0.2956)***
P^4	-	-	-	-0.2941(0.01849)***
n	44	44	44	44
r^2	0.0146	0.7825	0.9486	0.9931

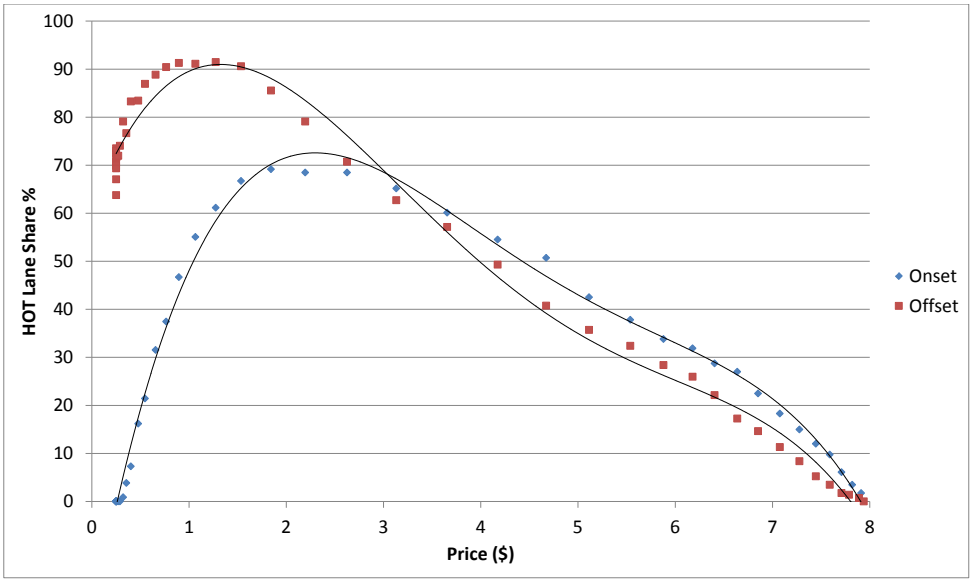
(Standard error in parentheses)
*Significance * 0.05, ** 0.01, *** 0.001*
$Pr(L|R)$ is dependent variable, P is price in USD

Table 6: Pricing Function Model Equations

Pricing Function	Model	r^2
	Onset	
$Continuous$	$Pr(L\|R) = -0.2941P^4 + 5.7446P^3 - 40.396P^2 + 108.91P - 25.884$	0.9931
$Unweighted$	$Pr(L\|R) = -0.1555P^4 + 3.6124P^3 - 31.812P^2 + 106.14P - 26.573$	0.9909
$HOT_{weighted}$	$Pr(L\|R) = -0.3468P^4 + 6.3111P^3 - 40.349P^2 + 98.579P - 22.116$	0.9493
$GP_{weighted}$	$Pr(L\|R) = -0.1785P^4 + 3.2471P^3 - 22.649P^2 + 66.301P - 13.515$	0.9604
	Offset	
$Continuous$	$Pr(L\|R) = -0.2394P^4 + 4.4049P^3 - 27.423P^2 + 51.688P + 61.127$	0.9904
$UnweightedValue$	$Pr(L\|R) = -0.1284P^4 + 3.0066P^3 - 23.308P^2 + 51.99P + 61.762$	0.9887
$HOT_{weighted}$	$Pr(L\|R) = -0.1652P^4 + 2.9438P^3 - 17.877P^2 + 29.923P + 69.300$	0.9801
$GP_{weighted}$	$Pr(L\|R) = -0.0546P^4 + 1.2879P^3 - 10.691P^2 + 22.483P + 68.142$	0.9905

P is price in USD

Figure 4: Continuous Pricing Function



$Pr(L|R) = -0.2941P^4 + 5.7446P^3 - 40.396P^2 + 108.91P - 25.884$
$r^2 = 0.9931$

8.1 Elasticity

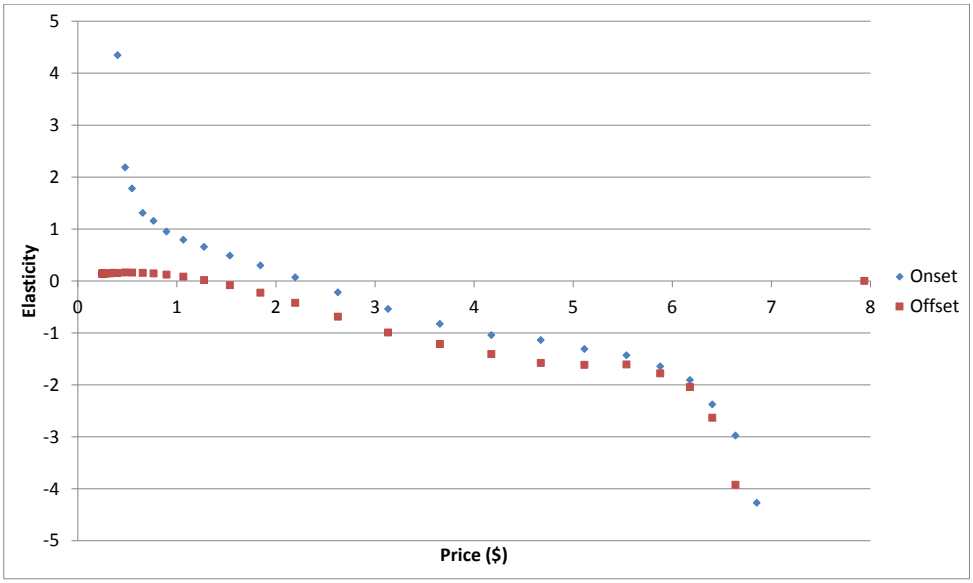
The functions above describe $Pr(L|R)$ as a function of toll price. The elasticity of $Pr(L|R)$ to price is determined by taking the derivative of the function and multiplying by the quotient of price

divided by $Pr(L|R)$.

$$\varepsilon_{Pr(L|R)(P)} = \frac{P * Pr(L|R)'(P)}{Pr(L|R)(P)} = \frac{dlnPr(L|R)(P)}{dlnP} \tag{9}$$

5 grahps elasticity as a function of price for the continuous function pricing strategy (onset and offset). The elasticity equations are displayed below each figure.

Figure 5: Continuous Pricing Function



$\varepsilon_{Pr(L|R)(P)} = \frac{P*(-1.176*4*P^3+17.23*P^2-80.79*P+108.9)}{Pr(L|R)(P)}$

$\varepsilon_{Pr(L|R)(P)} = \frac{P*(-0.9576*P^3+13.21*P^2-54.85*P+51.69)}{Pr(L|R)(P)}$ *where p is price in USD*

9 Discussion

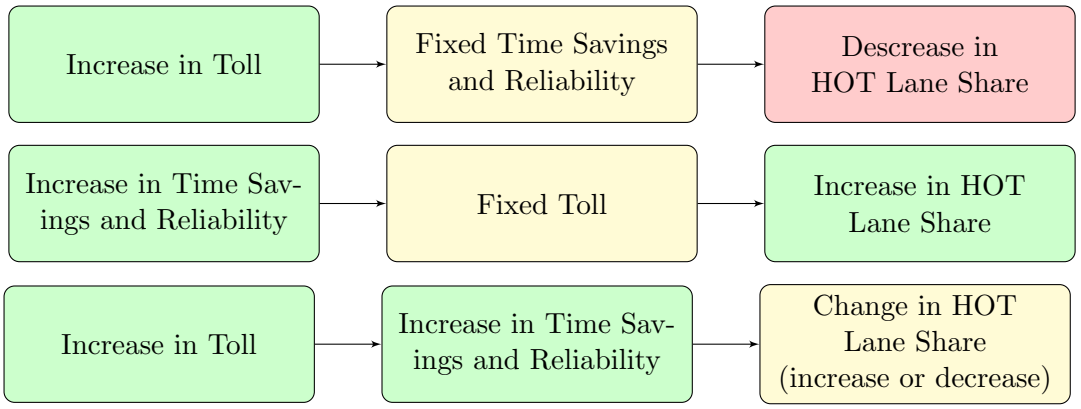
All four pricing strategies show a similar pattern in the relationship between $Pr(L|R)$ and price. The maximum $Pr(L|R)$ during congestion onset is achieved between \$2 and \$3, whereas during congestion offset, the greatest $Pr(L|R)$ occurs between \$1 and \$2. In general, the $Pr(L|R)$ during congestion offset is greater than during the onset due to the greater time savings and reliability per dollar toll price as demonstrated previously in 1 and 2. Table 7 shows the average price and $Pr(L|R)$ for each pricing strategy along with the standard deviation.

Table 7: Average $Pr(L|R)$ and Prices

Pricing Strategy	Avg Price ($)	Std Dev Price ($)	Avg $Pr(L\|R)$ (%)		Std Dev $Pr(L\|R)$ (%)	
			Onset	Offset	Onset	Offset
Continuous	2.93	2.93	54.6	24.4	31.6	24.7
Unweighted	3.19	3.20	54.1	24.5	36.9	32.6
HOT Weighted	3.65	2.93	49.4	24.5	31.6	19.3
GP Weighted	3.83	3.26	45.5	18.9	34.0	21.0

Figure 4 shows the rise and fall of the $Pr(L|R)$ as the toll increases (and therefore, time savings). When $Pr(L|R)$ reaches its maximum, elasticity switches from positive to negative. Figure 6 outlines how changes in toll and time savings affect $Pr(L|R)$ and ultimately, elasticity to price.

Figure 6: Toll and Time Savings Effect on $Pr(L|R)$



At lower tolls, an increase in price results in a higher $Pr(L|R)$ (positive elasticity), whereas at higher tolls, an increase in price causes a decrease in $Pr(L|R)$ (negative elasticity). At lower tolls, the improved time savings and reliability outweigh the increase in toll. However, at higher tolls, the increase in toll outweighs greater time savings and reliability causing the $Pr(L|R)$ to decrease.

10 Conclusion

This paper outlined four HOT lane pricing strategies which could serve as alternatives to the current MnPASS pricing system. The current system relies on a series of density and price tables to determine the toll based strictly on HOT lane density. The proposed alternatives determine the toll based on a simple mathematical function relating HOT lane density (and GP density in three of the strategies) to price. The three value pricing strategies use the difference in GP and HOT lane density to determine the toll. Due to the nonlinear relationship between density and time savings, two of the strategies are weighted by either HOT density or GP density. The $HOT_{weighted}$ strategy combines the value pricing concept with the current algorithm's direct correlation between HOT density and price. For this reason, this pricing strategy would provide the greatest improvement

over the current pricing system while still maintaining some of the same logic. The continuous function, on the other hand, most closely resembles the current pricing system, but fails to account for the density in the GP lanes.

The behavior of the four alternative pricing strategies was tested using a fixed demand partial equilibrium analysis. Using a calibrated lane choice model, simulated vehicles made decisions on whether to use the MnPASS lane based on the toll and their anticipated time savings and improved travel time reliability. The $Pr(L|R)$ was determined at various price increments for each pricing system. These were plotted and fit with a fourth degree polynomial, the derivatives of which correlate to the elasticity to price. In all cases, demand elasticity to price was positive at lower tolls and negative at higher tolls. MnPASS users recognize the correlation between the toll price and the time savings and travel time reliability provided by the lanes. The toll price acts as a proxy of downstream congestion. At lower tolls, the travel time savings and reliability advantages outweigh the cost of the toll and $Pr(L|R)$ rises. However, at higher tolls, the cost of using the lane begins to outweigh the benefit and the $Pr(L|R)$ drops.

These results are estimated on a system where drivers have incomplete information about travel time savings from HOT lane usage, and use price as a signal of time savings. In a context where drivers were better informed (e.g. through Variable Message Signs or real-time congestion-aware GPS navigation systems), results would likely be significantly different.

Future research should field test alternative pricing strategies and parameter values to identify which best achieves the goals of maximizing use of the HOT lanes while maintaining reliabile free-flowing speeds, recognizing that travelers may change their sensitivity to price if the relationship between price and travel time savings changes.

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