MnPASS Pricing and Its Benefits to Drivers

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Introduction

The MnPASS system allows solo drivers to travel in carpool lanes for a fee. The system was implemented in 2005 when it was clear that carpool lanes on I-394 were underutilized. Drivers purchase a transponder that reports when they are using the carpool lane—now called the High-Occupancy Toll (HOT) lane. This article uses real data to determine the impact of that system on traffic flows and to document the benefits. The research finds this real-time pricing system is working well for both those in the HOT lane and those in general-purpose lanes.

The goal of the MnPASS system is to reduce congestion, with an emphasis on keeping those in the HOT lanes moving at a minimum of 50 mph. Solo drivers with transponders can choose to travel free in the general-purpose lanes—or to pay a fee, in the form of an electronically collected toll, to travel in the HOT lane.

MnDOT uses a real-time pricing system that adjusts the prices every 3 minutes based on traffic flows. Higher prices are charged when the system senses congestion in the HOT lane. Total costs can be as high as $8 for a trip from the western suburbs to downtown Minneapolis. Higher prices signal solo drivers about congestion ahead, forcing them to decide between a faster trip in the HOT lane and a no-cost but slower trip in the general-purpose lanes.

The I-394 MnPASS system is shown in Figure 1. It covers the full length of road, from I-494 in the west to I-94 in the east, and provides the major access link to downtown for commuters in the western suburbs. The system consists of two segments. West of Highway 100, the HOT lane is separated from general-purpose lanes by double-painted lines and marked with diamonds. Between Highway 100 and downtown, a 3-mile-long reversible segment is situated between the eastbound and westbound lanes, separated by concrete barriers. For inbound motorists, there are four separate entrances to the diamond lanes and one entrance to the reversible lanes.

Quantifying motorists' values of time on the road is crucial to understanding the policy implications of real-time pricing. To measure motorists' value of time on the road, a data set that reflects how motorists make entry decisions on the road was necessary. The data used contain de-identified MnPASS data from October 2009.

Basic MnPASS Entry Decision

Consider a morning commuter heading to downtown Minneapolis from her home in the western suburbs, somewhere west of I-494. She is driving alone but has a MnPASS transponder and can choose to use the HOT lane if it makes sense to her. MnPASS posts the current toll at her entrance to help make her decision. Once she enters the MnPASS lane, she has locked in that toll all the way to downtown.

Our driver will be trying to minimize her total cost: a combination of toll price and travel time. When the price is low, she might opt to take the HOT lane. As the price goes up, she is less likely to pay the HOT lane toll. A look at Table 1 showed this to be true for drivers in the 2009 data set. When the toll was $0.75, 70% of them took the HOT lane, but that percentage dropped to 60% when the toll rose to $1.00 and continued to drop as the price rose. At $1.50, only 31% were willing to pay the toll required to travel the HOT lane.

Table 1. Percent of MnPASS Subscribers Who Choose HOT Lane at Western End of I-394 at Different Toll Prices (author estimates based on real data from October 2009)

Price	Percent Entering HOT lane
$0.75	70%
$1.00	60%
$1.25	59%
$1.50	31%
$1.75	67%
$2.00	63%
$2.25	55%

But our driver knows that the higher toll amount is a signal of congestion ahead and will start paying again as the price gets to some intermediate point. In our 2009 data set, drivers sense congestion ahead at a price of $1.75 and 67% became willing to pay the toll again. Eventually, the toll became too high and drivers became more willing to stay in the general-purpose lanes despite the increased travel time.

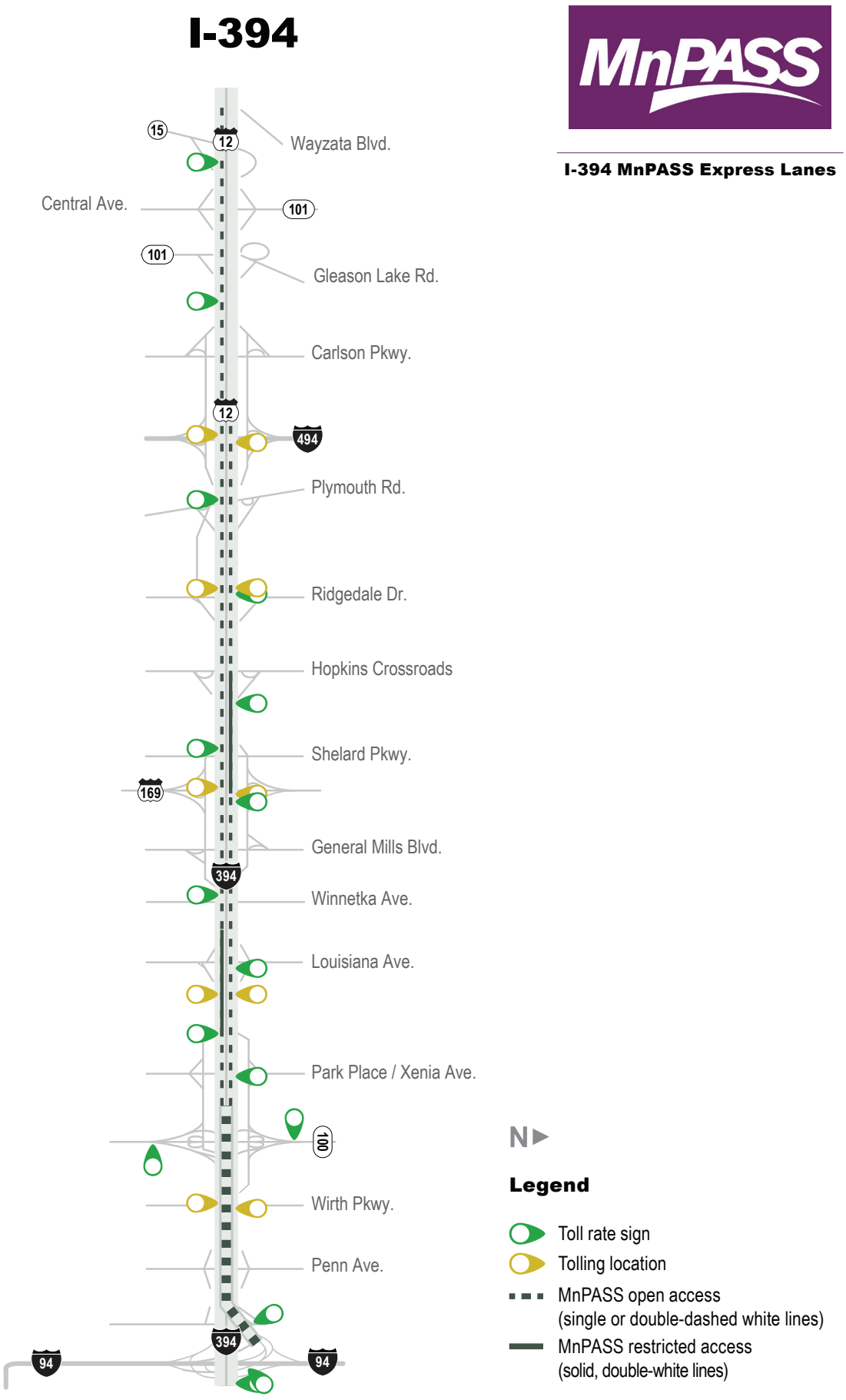
What Is Driver Time Worth?

Estimating subscribers' value of time on the road is a two-step process: (1) estimate the evolution of downstream congestion and prices based on current conditions using minute-level traffic and pricing data, and (2) estimate subscribers' value of time using the entry model and the first-stage estimates to match subscribers' entry decisions on the road.

To make these estimates, I took advantage of the dual price postings MnDOT places on its toll signs. I focus on the experience of the eastbound morning commuter. Figure 2 shows Interstate 394 in Minnesota, with a MnPASS toll lane at left shows the HOT lane, and Figure 3 provides examples of the HOT prices presented to solo drivers who have the option of using the HOT lane. The top number shows the price to Highway 100, and the bottom number shows the total price all the way to I-94 (and downtown). That last segment of I-394, the 3-mile line reversible section of road, can be the most congested of the general-purpose lanes, so drivers will be watching for clues that might draw them toward the HOT lanes and an easier ride.

The bottom number can signal congestion on that final segment. MnDOT raises the price on the HOT lane as drivers ahead move to those lanes to avoid congestion on the general-purpose lanes. MnDOT does this to discourage too many drivers from moving to the HOT lane and

Figure 1. I-394 MnPASS Segments and Entrances



MnDOT website

Figure 2: Interstate 394 in Minnesota, with a MnPASS toll lane at left

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Figure 3: Example of MnPASS Toll Rate Sign (eastbound, approaching US Highway 169)
Top rate is the price to travel the HOT lane from here to MN Highway 100. Bottom rate is the total price from here to I-94 (and downtown).

MnDOT website

Eastbound dynamic pricing showing the cost to go to Highway 100 and then all the way to I-94 downtown.

slowing speeds below 50 mph. The last segment is accessed just before the intersection with Highway 100. I looked at the price signaled earlier at Louisiana Avenue for the final section of MnPASS to downtown. That price covers both the last section "diamond" segment of the HOT lane and the "reversible" segment.

My first task was to estimate probabilities of downstream congestion and prices. The top part of Table 2 shows the distribution of the general-purpose lane speed on the Highway 100 to I-94 segment conditional on the HOT price presented at Louisiana. Results show the probability of observing a higher travel time in the general-purpose lanes increases with the price presented at Louisiana. For example, the probability of no congestion (travel time equal to 3 minutes) is 83% if the price at Louisiana is $0.50 but decreases to 41% if the price at Louisiana is $0.75, and 15% if the price is $1.00. The probability that congestion occurs increases as the Louisiana price rises. For example, the probability that travel time equals 4 minutes is 10% if the price at Louisiana is $0.50 but 32% if the price at Louisiana is $0.75 and 53% if the price at Louisiana is $1.00. These numbers helped me understand the probabilities facing drivers who have a choice to avoid congestion.

The other issue those drivers consider in making their decisions is price. The total HOT price shown at Louisiana Avenue from there to I-94 is a fairly good predictor of what the price will be for the Highway 100 to I-94 segment alone, but it's not perfect. Those prices help solo drivers with transponders estimate what their costs will be for traveling the reversible segment. The bottom part of Table 2 shows that the probability of encountering a higher price at the entrance to the reversible segment increases with the price shown at Louisiana Avenue, helping drivers decide whether to enter the HOT lane at that point. The prices shown at Louisiana, therefore, provide signals of both travel time and price over the most congested segment of I-394. Using that information, I can estimate the trade-offs as drivers make the decision about whether or not to enter the HOT lane.

Using that information, my estimates show the average value of time of MnPASS subscribers is $62 per hour, with a standard deviation of $23 per hour. This is equivalent to an annual income of $120,624, which is similar to the annual income of many commuters traveling on the highway. According to the 2007–2011 American Community Survey, the mean household incomes are $116,668 and $131,035 of two neighborhoods at the first two entrances of MnPASS. (Even lower-income commuters will pay that price if time is critical to them. Furthermore, the HOT lanes add comfort and safety not available in congested traffic.)

Efficiency Benefits

In this section, I address two policy questions through further modeling of the MnPASS data. First, what are the efficiency gains from the HOT lane? Second, how does the MnDOT pricing scheme compare to alternatives, notably

the fixed peak-load approach used in some other cities?

To look at efficiency gains, I developed a model where subscribers could not access the HOT lane. The experiment was to measure the efficiency loss when the HOT lane unexpectedly shuts down for one day. The current MnPASS system reduces traffic delays by 416 hours on an average day. Subscribers spend 208 hours less, net of toll payments. Nonsubscribers are also better off since the regular lanes are faster under MnPASS. They spent 258 hours less on the road per morning. Carpools are slightly worse off due to the extra traffic in the HOT lane; aggregately, they spend an extra 50 hours per morning. Overall results suggest that MnPASS increases motorists' welfare by 8%.

In looking at other pricing structures, I first compared MnDOT's dynamic real-time pricing system to the more traditional peak-load approach, where the price varies by time of day without regard to current conditions, like rush-hour pricing on MetroTransit. Results show that the current real-time pricing function is more efficient than peak-load pricing. Motorist welfare would decrease by 3% if MnDOT's real-time pricing were switched to even the best peak-load pricing scheme.

Then I looked at other pricing structures. It might be possible to improve upon the current real-time pricing system, which solely depends on traffic in the express/HOT lane. Consumers' entry decisions are actually based on the *relative* traffic conditions between the regular and the HOT lanes. Consumers leave the regular lanes when they are slow and the HOT lane looks like a better option. Using this consumer perspective, I developed an alternative pricing function that depends on the relative speed between the regular and express lanes rather than the speed in the express lane alone. I find that the alternative pricing function could improve consumer welfare by an additional 5%. Nothing is guaranteed, but such an option should be considered.

Table 2. Probable Driver Experiences on Highway 100 to I-94 Segment of I-394 Based on MnPASS Prices Given at Louisiana Avenue (one entrance earlier)

		MnPASS Price to I-94 Shown at Louisiana Ave		
		$0.50	$0.75	$1.00
Minutes from Highway 100 to I-94 for travelers in regular lanes	3	83%	60%	24%
	4	10%	32%	53%
	5	3%	4%	7%
	6+	4%	4%	6%
MnPASS Price at entrance to Highway 100 to I-94 segment	$0.25	81%	41%	15%
	$0.50	16%	55%	63%
	$0.75	1%	1%	18%
	$1.00+	2%	3%	4%

Chunying Xie received her Ph.D. in Economics from the University of Minnesota in 2014. This work is based on her doctoral dissertation, *Essays in Industrial Organization*. **That work was supported, in part, by a Dissertation Research Grant from CURA.** **She is now working in the private sector.**