Benefit-Cost Analysis of Variable Pricing Projects: QuickRide HOT Lanes

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Abstract: Researchers identified a potential methodology for obtaining the incremental societal costs and benefits from a variable pricing project and applied that methodology to the QuickRide high occupancy/toll (HOT) lanes in Texas. This is one of the longest running variable pricing projects in the United States and, as such, it provided useful historical data and trends upon which to estimate future benefits and costs. This analysis found that the incremental societal benefits of QuickRide exceeded incremental societal costs for the time period considered. A companion paper that used the same methodology to examine the benefits and costs of the SR-91 Express Lanes found similar results. However, the differences between the benefits and costs were dramatically different for the two projects, indicative of the relative size of the two projects and the number of travelers impacted. On SR-91, tens of thousands of travelers were impacted on a daily basis where QuickRide’s impact was limited to approximately 400 travelers per day. Interestingly, the benefit-cost ratios of the two projects were similar, both between 1.5 and 1.7.

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CE Database subject headings: Benefit cost ratios; Pricing; Tolls; High occupancy vehicles; Texas; Traffic management.

Introduction

Facing increasing difficulties in funding transportation infrastructure improvements to handle ever increasing traffic congestion (Schrank and Lomax 2002), agencies in charge of highway transportation are increasingly considering the application of value pricing to their roadways. Value pricing includes (FHWA 2002):

1. Managing demand through tolls that vary by time of day, day of week, or season;
2. Using flat or variable tolls to efficiently preserve congestion-free use of both new and previously existing spare capacity, such as in high occupancy/toll (HOT) lanes;
3. Cordon and area pricing with flat or variable tolls;
4. Priced queue-jumps and other congestion-bypass facilities;
5. Converting traditionally fixed costs (insurance, registration, etc.) to variable costs;
6. Cash out of subsidized employee parking; and
7. Car sharing.

The first four methods listed above have the potential to use tolls to both help finance infrastructure improvements and manage congestion—dealing with two of the critical dilemmas facing transportation agencies. Some pricing methods increase options available to travelers in the form of both premium and discount services such as access to a faster lane (methods 2 and 4), and discounts for adjusting time of travel (methods 1 and 3). Variable pricing is a feature of many value pricing projects, where tolls vary by time of day. These pricing strategies reduce traffic demand for the most congested times and locations, improving traffic flow.

In theory, the use of variable pricing in the form of marginal cost pricing has been shown to maximize net societal benefits (Walters 1968; Hau 1992; Small and Gomez-Ibanez 1997; Mohring 1999). These benefits occur because the total cost of travel (marginal social cost) exceeds the average private cost paid by drivers during congested periods (see Fig. 1). This disparity leads to an inefficiently high demand (q1 in Fig. 1) and a welfare loss (the hatched area of Fig. 1). The optimal traffic flow (q2)
occurs at the point where the demand for travel (Curve D-D in Fig. 1), which measures the marginal benefit to users of each additional trip, intersects the marginal social cost curve. At the optimum flow, $q^*_2$, any increase or decrease in traffic would decrease the net societal benefits derived from the use of the road. In theory, the optimal flow of traffic can be achieved if drivers are charged a toll of $\tau$.

Planners, engineers, and economists have developed theoretical models to predict the impact of congestion pricing (both in its pure marginal social cost pricing form and using variations of marginal social cost pricing). Applying these models to actual traffic conditions, researchers predicted the resulting societal costs and benefits (Hyman and Mayhew 2002; May et al. 2002; Santos and Rojey 2003). In almost every case, societal benefits exceeded societal costs—although the impacts were often regressive to neutral with respect to the relative benefits enjoyed by different income groups. To improve the equity of the pricing program some writers examined various toll revenue allocation schemes (Small 1992; Litman 1999; Parry and Bento 1999).

Despite these findings, many transportation agencies remain reluctant to proceed with variable pricing projects. Part of this reluctance may stem from the lack of actual empirical data on the benefits and costs of operational variable pricing projects. This lack of actual data is not surprising since only 19 variable pricing projects have been implemented (Burris and Pendyala 2002), and many of those have been implemented too recently to provide the data required for a benefit-cost analysis (BCA). This research was undertaken to provide an empirical reference point by performing a BCA on one of the US’s longest running projects: the QuickRide Program (HOT lanes), in Houston (see Fig. 2). (A companion paper used the same methodology to perform a BCA for the SR-91 Express Lanes.)

In analyzing this project, researchers used 4 years of historical data to derive historical costs and benefits and to project future costs and benefits. Based on these data, net societal benefits exceeded costs for the period considered, although the difference was small.

The next section of the paper includes an overview of the BCA methods used. In the succeeding section the benefits and costs of the variable pricing project are documented. The last section of the paper includes a summary and conclusion.

Framework for the Benefit Cost Analysis

In this research, the net incremental societal benefits and costs of a variable pricing project were quantified. This included the incremental benefits and costs resulting from the implementation of the variable pricing project, but did not include any transfers of wealth among different groups. In such an analysis it is critical to carefully define the attributes of the “base case” scenario. This scenario did not exist, but rather it is what would have likely occurred if the variable pricing project had not been undertaken. As such, it provides the reference point against which the incremental societal costs and benefits of the variable pricing project are measured. Our base case assumed that the HOT lanes in Houston continued to operate as HOV lanes, without ever incorporating the option of toll paying travelers (see the following section for details specific to the individual project).

The variable pricing project examined here, along with most pricing projects around the world, rely on electronic toll collection (ETC) for vehicle identification and toll payments. ETC equipment has a limited life span, and therefore benefit-cost analyses of ETC projects (along with other intelligent transportation system projects) typically examine benefits and costs for a 10-year time frame (USDOT 2002). This research also used a 10-year time frame for cost and benefit streams. Although this may be seen as conservative, it was appropriate since one of the HOT lanes was slated to undergo major reconstruction and expansion after this time period. All benefits and costs were converted to year 2002 dollars using discount and inflation rates published by the federal government (real=3.1%, nominal=5.1%, inflation=1.9%) (OMB 2002).

Benefits

In general, the benefits travelers derive from making trips is measured by the area formed between the demand curve (D-D in Fig. 1) and the horizontal line indicating the cost of travel at the given demand (line $p_1$ in Fig. 1). If a change in transportation infrastructure or travel options causes the area between these two curves to increase then the change results in a net benefit for those travelers. As discussed previously, society as a whole benefits to the maximum extent possible when the cost of the trip equals the marginal social cost—eliminating the welfare loss caused primarily by the additional time penalty each new vehicle imposes on existing drivers under congested conditions. Unfortunately, the shapes of these curves are generally unknown and calculating a change in benefits often amounts to estimating the change in travel costs for travelers and aggregating these changes.

It is common to estimate user cost changes due to changes in travel time savings, vehicle operation and ownership costs, and safety improvements (USDOT 2000; AASHTO 2003). However, cost savings associated with safety were not examined here because the accident rates for the travel options were similar and no benefits were assumed from a safety aspect. One additional item examined here was costs associated with emissions, due to the increased interest in such impacts.

Travel Time Savings

The benefits of this variable pricing project, and the majority of transportation improvements, are dominated by travel time savings. Although it is relatively straightforward to estimate the amount of travel time saved due to a transportation improvement, it is far more difficult to determine the value of that travel time saved. A great deal of research has focused on determining proper values of time (VOT) (Calfee and Winston 1998; Small et al. 1999; Bates et al. 2001; Hensher 2001). Much of this research has found that the values of time for commute trips range from 20% to over 50% of the drivers’ wage rates (USDOT 2003). These values have been shown to increase with increased traffic congestion (Small et al. 1999), and there was considerable traffic congestion in the free lanes beside the variable pricing project examined.

The VOT was further refined in this research based on the premise that, other things being equal, people who chose to pay tolls to avoid congestion must have had values of time at least equal to the toll divided by the amount of time saved. Similarly, people who chose not to pay tolls to avoid congestion would usually be expected to have had values of time less than the toll divided by the time that could have been saved. However, this simple premise was complicated by eligibility issues, such as the requirement to have a transponder in order to use these toll facilities.
Vehicle Operating and Ownership Costs

Another potential benefit derived from roadway improvements is the reduction in vehicle operating and ownership costs. In this application, since the distance traveled for each option was identical, it was assumed that there would be no significant difference in ownership costs and the bulk of operational cost savings would be derived from any reduction in fuel consumption. Based on the changes in speeds caused by the variable pricing project, the changes in fuel consumption were estimated using Fig. 3 (West et al. 1999).

The total change in fuel consumption was converted to a dollar value based on the price of fuel at the pump (approximately $1.50 in 2000). Taxes were subtracted from the pump price because taxes are transfers of wealth and should not be included in calculating incremental societal costs and benefits. The net benefit from reducing fuel consumption was valued at approximately $1.12 per gallon (year 2000 dollars).

Emissions

The final benefit category considered was the change in vehicle emissions. The changes in emissions were found using Mobile 5b in Houston and the California EMFAC model for SR-91 in the companion paper (CARB 1996; Barth et al. 2001; CARB 2003). Mobile is the mobile source emissions estimation program used in the majority of the United States while EMFAC is specifically calibrated for the California vehicle fleet. Once the changes in the quantities of pollutants [nitrous oxides (NOx), volatile organic compounds (VOC), carbon monoxide (CO), and (in California) particulate matter (PM10)] were determined, the values of these changes were estimated using default values shown in Table 1.

To convert emissions to monetary values, the costs associated with most pollutants were obtained from research done by Delucchi (2000) and Small and Kazimi (1995) (see Table 1). Both of these sources based their costs of emissions on the cost of health care to treat diseases related to the emissions of motor vehicles. The values used in this analysis were on the conservative end of the estimates. In the case of PM10 emissions (in California), the unit cost of $12.17/kg was adopted, which is the default value used in the Federal Highway Administration (FHWA) STEAM model (FHWA 2003). Costs were inflated according to an average health care index (+3.5% per year, USHCF 2001) to calculate values for the entire evaluation period.

Costs

Incremental costs were more straightforward to estimate. All costs (excluding transfers) that the agency incurred due to the project were included. Start up costs were amortized over the 10 years evaluation period and added to any operation and maintenance costs of the project over and above costs that would have occurred under the base case scenario.

Benefit-Cost Analysis of Houston Quickride

For the analysis period, the Houston QuickRide project consisted of high occupancy/toll (HOT) lanes on the Katy Freeway (I-10) and Northwest Freeway (US 290) in Houston (see Fig. 2). Each highway had one barrier-separated reversible high occupancy vehicle (HOV) lane that was open on weekdays 5–11 a.m. inbound and 2–8 p.m. outbound. Normally open to HOV 2+ vehicles, the lanes were restricted to HOV 3+ vehicles during 6:45–8:00 a.m. on both freeways and 5:00–6:00 p.m. on Katy Freeway. However, HOV 2+ drivers who registered for the QuickRide program could use the lanes during these hours if they paid a $2 toll per trip. In this way the toll paid by HOV2 travelers on the HOV lane varied by time of day, with the peak period costing $2 and the off-peak having no toll.

The HOV lane on the Katy Freeway was constructed in 1984. The lane was originally restricted to buses and vanpools but the lane operator quickly relaxed these restrictions to accept any HOV 2+ vehicle. By 1988, the need to alleviate congestion led to the additional occupancy restrictions during the morning peak hour. The afternoon peak period followed shortly after. The same restrictions were later placed on the HOV lane on the Northwest Freeway during the morning peak period. This was how the HOV lanes operated for several years prior to QuickRide beginning in mid-January 1998 on the Katy Freeway and November 2000 on the Northwest Freeway.

Prior to QuickRide, the increased occupancy restriction eliminated HOV lane congestion, but resulted in significant excess capacity (Burris and Hannay 2003). This was chosen as the base case against which the costs and benefits of QuickRide were compared. In this base case, which assumed no QuickRide, HOV2 vehicles could not legally use the HOV lane during the HOV 3+ restricted periods. The analysis covered the time period

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**Table 1. Unit Values of Emission Reductions**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>NOx</td>
<td>Low 1.59/kg</td>
<td>High 23.34/kg</td>
<td>1.33/kg</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1.59/kg</td>
</tr>
<tr>
<td>VOC</td>
<td>0.13/kg</td>
<td>1.45/kg</td>
<td>1.71/kg</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1.45/kg</td>
</tr>
<tr>
<td>CO</td>
<td>0.01/kg</td>
<td>0.10/kg</td>
<td>0.0063/kg</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.01/kg</td>
</tr>
<tr>
<td>PM10</td>
<td></td>
<td></td>
<td>12.17/kg</td>
</tr>
</tbody>
</table>
from mid-January 1998 to mid-January 2008, corresponding to 10 years of QuickRide usage on the Katy Freeway and just over 7 years on the Northwest Freeway.

**QuickRide Benefits**

The number of QuickRide trips was determined using a database that contained all recorded QuickRide trips. Future QuickRide usage was estimated to be the average of volumes for the years 2002 and 2003. This was likely a conservative estimate as it assumed a 0% growth in the number of QuickRide trips.

For each of these trips it was assumed that the benefits derived from using QuickRide exceeded the benefits derived from the travelers’ alternative methods of travel. The most probable travel alternatives are listed in Table 2. Note that the data in Table 2 can be considered only rough estimates since they were obtained in 1998 and did not include US 290 travelers.

Each of these travel options provided a reduced utility for travelers with respect to using QuickRide. It is extremely difficult to both (1) quantify the number of current QuickRide trips that would fall into each of the categories in Table 2 and (2) to quantify the additional benefits of a QuickRide trip versus each alternative. Therefore, in this analysis, the benefits of QuickRide were derived by comparing a QuickRide trip to a single occupancy vehicle (SOV) trip at the same time on the general purpose lanes (GPL). Thus the additional benefits derived from using QuickRide compared to SOV travel were assumed to be similar to the benefits of QuickRide compared to other travel options. For example, this assumes benefits derived by HOV2 travelers who used to travel during the off-peak period but could now drive at their preferred time of travel in the HOT lanes using QuickRide were similar to the benefits derived by an SOV peak-period traveler switching to HOV2 and using the HOT lane as a QuickRide traveler.

**Value of Travel Time Savings**

To determine the travel time savings gained by using the HOT lanes, vehicle travel times on both the GPLs and the HOT lanes were analyzed. The dataset used included several million speed entries for individual vehicles based on their actual travel times between several automatic vehicle identification (AVI) readers placed along the HOT and general purpose lanes (GPLs) of the Houston freeways (data available at http://traffic.tamu.edu). Using these data, the average travel speeds on both the HOT and GP lanes were found for each 15-min period, on each highway, for each year, using Eq. (1)

\[
\text{average speed} = \frac{\sum_{\text{segments}} \left( \frac{\sum_{\text{users}} \frac{\sum_{\text{observations}}}{1} \times \text{length}_{\text{segment}}}{\text{work days}} \right)}{\# \text{ work days in year}} \times \text{length}_{\text{segment}}
\]

Eq. (1) was used to determine the average space mean speed (Banks 2002) weighted by the number of observations for a given segment and the length of that segment. To determine the travel time savings, these average speeds plus the average distance traveled on the HOT lanes were required. Survey data from QuickRide users, taken in 1998, was used to find that the average distance traveled on the Katy HOT lane by QuickRide users was 11 mi (2.3 mi less than the length of the facility). For the Northwest Freeway, data on entry and exit of all vehicles on the HOT lane was used since there were no data on QuickRide users alone. Assuming QuickRide trips were of similar length as all HOT lane trips, the average distance traveled was 10.6 mi (3.1 mi...
less than the length of the facility). Using these data the average travel time savings of travel in the HOT lanes versus the GPLs was determined. Next, the average carpool formation time of 4.33 min (from the survey of drivers) was subtracted to account for the time lost in forming carpools. These average travel time savings for each year (see Table 3 for representative values for a single year) were entered into Eq. (2) to determine the total value of travel time savings.

\[
VTTS = \sum_{y=1}^{10} \left[ VoT_y \times \sum_{i=1}^{9} (TS_{yi} \times Veh_{yi}) \times QRdays_y \right]
\]  

(2)

where VTTS = value of travel time savings ($)(year 2002 dollars); 1–10; these indicate the 10 years of QuickRide usage examined (the first three on US 290 had 0 VTTS); VoT = value of time in year y = $15.56 per person-hour, $31.13 per vehicle-hour in 2002 and adjusted by the discount rate (3.1%) for other years. This was based on 35% of the wage rate of QuickRide users (from the survey) and $0 for children (who comprise approximately 21% of QuickRide carpool passengers); i=1–9; these indicate the nine, 15-min time segments (as shown in Table 3) for the Katy Freeway or i=1–5 for the five, 15-min time segments on the Northwest Freeway; TS = travel time saved by traveling in the HOT lane compared to the GPLs (h); Veh = average number of vehicles per day that used QuickRide (vehicles/day); and QRdays = number of QuickRide days per year, typically just over 250 per year. The total value of travel time savings over the entire period (converted to year 2002 dollars) was $2.36 million.

**Fuel Usage**

The fuel saved by QuickRide users versus GPL users was estimated using travel speeds from the GPLs and HOT lanes. The localized travel speeds were converted to fuel use (gal/mil) using Fig. 3. The results for the HOT lanes were likely to be more accurate than for the GPLs because vehicle speeds on the HOT lanes contained much less variability (see Fig. 4) and therefore

\begin{figure}
\centering
\includegraphics[width=\textwidth]{fig3.png}
\caption{Fuel consumed versus travel speed (data from West et al. 1999)}
\end{figure}

\begin{figure}
\centering
\includegraphics[width=\textwidth]{fig4.png}
\caption{Speed distributions on the HOT and GP lanes}
\end{figure}
As with fuel consumption, vehicle emissions increase significantly in stop and go traffic. The fact that speed data contained only average speeds over 1–5 mi segments reduced the ability to accurately account for stop and go conditions on the GPLs; and

Table 4. 2003 Fuel Consumption (FC) Savings on Katy Freeway

<table>
<thead>
<tr>
<th>Time</th>
<th>Vehicles (per day)</th>
<th>FC\textsubscript{GPL} (gal/veh mi)</th>
<th>FC\textsubscript{HOT} (gal/veh mi)</th>
<th>Daily fuel savings (gal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6:45–7:00 a.m.</td>
<td>8.59</td>
<td>0.024</td>
<td>0.022</td>
<td>0.3</td>
</tr>
<tr>
<td>7:00–7:15 a.m.</td>
<td>15.68</td>
<td>0.025</td>
<td>0.021</td>
<td>0.7</td>
</tr>
<tr>
<td>7:15–7:30 a.m.</td>
<td>21.22</td>
<td>0.026</td>
<td>0.020</td>
<td>1.4</td>
</tr>
<tr>
<td>7:30–7:45 a.m.</td>
<td>22.71</td>
<td>0.027</td>
<td>0.021</td>
<td>1.6</td>
</tr>
<tr>
<td>7:45–8:00 a.m.</td>
<td>15.81</td>
<td>0.027</td>
<td>0.021</td>
<td>1.1</td>
</tr>
<tr>
<td>5:00–5:15 p.m.</td>
<td>9.28</td>
<td>0.032</td>
<td>0.021</td>
<td>1.1</td>
</tr>
<tr>
<td>5:15–5:30 p.m.</td>
<td>17.43</td>
<td>0.037</td>
<td>0.021</td>
<td>3.1</td>
</tr>
<tr>
<td>5:30–5:45 p.m.</td>
<td>15.97</td>
<td>0.037</td>
<td>0.021</td>
<td>2.8</td>
</tr>
<tr>
<td>5:45–6:00 p.m.</td>
<td>11.35</td>
<td>0.034</td>
<td>0.020</td>
<td>1.7</td>
</tr>
<tr>
<td>Total</td>
<td>138.04</td>
<td></td>
<td></td>
<td>13.8</td>
</tr>
</tbody>
</table>

$\times 254$ days $\times $1.13/gal = $3,980$

Table 5. Weighted Average Emission Savings (2002)

<table>
<thead>
<tr>
<th>Time period</th>
<th>VOC (g/veh)</th>
<th>CO (g/veh)</th>
<th>NO\textsubscript{x} (g/veh)</th>
<th>Total (g/veh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Katy a.m.</td>
<td>5.3</td>
<td>35.2</td>
<td>−6.8</td>
<td></td>
</tr>
<tr>
<td>Katy p.m.</td>
<td>6.1</td>
<td>67.0</td>
<td>−5.0</td>
<td></td>
</tr>
<tr>
<td>US 290 a.m.</td>
<td>3.6</td>
<td>7.9</td>
<td>−6.9</td>
<td></td>
</tr>
</tbody>
</table>

2. If QuickRide did not exist, over half of the QuickRide travelers would have chosen to travel in SOVs. Therefore each QuickRide vehicle corresponded to more than one vehicle removed from the GPLs. However, we conservatively assumed a one-to-one vehicle replacement in this calculation.

Calculation of the changes in emissions was done in much the same manner as fuel consumption, as shown in Eq. (4) and Table 5

$$PR = \sum_{p=1}^{3} \sum_{y=1}^{10} \left\{ \text{CoP}_{pi} \times \sum_{i=1}^{9} \left[ (\text{PE}_{mly} - \text{PE}_{HOT})_{yi} \times \text{Veh}_{yi} \times D \right] \right\} \times \text{QRdays}_{y}$$

where $PR =$ value of pollution reduction (in 2002 dollars) due to all QuickRide users; $p = 1–3$; these indicate the three pollutant species (VOC, NO\textsubscript{x}, SO\textsubscript{2}) examined; $y = 1–10$; these indicate the 10 years of QuickRide usage examined; $\text{CoP}_{pi} =$ cost of pollutant (see Table 1 ($/kg$) in year $y$ adjusted for other years using the discount rate of 3.1%); $i = 1–9$; these indicate the nine, 15-min time segments (as shown in Table 4) for the Katy Freeway or $i = 1–5$ for five, 15-min time segments for the Northwest Freeway; $\text{PE}_{mly} =$ pollutant emitted on the GPLs or the HOT lane as a function of speed (based on Mobile 5a) (kg per mile). Veh = average number of vehicles per day that used QuickRide (vehicles/day); $D =$ average distance traveled per vehicle, 11 mi on Katy, 10.6 mi on US 290; and QRdays = number of QuickRide days per year, typically just over 250 per year.

An example of this is shown in Table 6. The total benefit from reduced vehicle emissions on both freeways was found to be $−11,100. The shift from the GPLs to the HOT lane reduced the overall volume of pollutants. However, it was the pollutant with

Table 6. Values of Emissions Savings: Katy Freeway

<table>
<thead>
<tr>
<th>Year</th>
<th>QR (days)</th>
<th>VOC ($/gal)</th>
<th>CO ($/gal)</th>
<th>NO\textsubscript{x} ($/gal)</th>
<th>Total ($/gal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1998</td>
<td>238</td>
<td>164</td>
<td>2</td>
<td>−316</td>
<td>−150</td>
</tr>
<tr>
<td>1999</td>
<td>253</td>
<td>192</td>
<td>0</td>
<td>−416</td>
<td>−224</td>
</tr>
<tr>
<td>2000</td>
<td>254</td>
<td>181</td>
<td>0</td>
<td>−387</td>
<td>−205</td>
</tr>
<tr>
<td>2001</td>
<td>252</td>
<td>224</td>
<td>5</td>
<td>−405</td>
<td>−175</td>
</tr>
<tr>
<td>2002</td>
<td>253</td>
<td>264</td>
<td>15</td>
<td>−321</td>
<td>−42</td>
</tr>
<tr>
<td>2003</td>
<td>254</td>
<td>411</td>
<td>26</td>
<td>−367</td>
<td>70</td>
</tr>
<tr>
<td>2004</td>
<td>253</td>
<td>389</td>
<td>24</td>
<td>−353</td>
<td>60</td>
</tr>
<tr>
<td>2005</td>
<td>253</td>
<td>395</td>
<td>25</td>
<td>−358</td>
<td>61</td>
</tr>
<tr>
<td>2006</td>
<td>253</td>
<td>400</td>
<td>25</td>
<td>−363</td>
<td>62</td>
</tr>
<tr>
<td>2007</td>
<td>253</td>
<td>406</td>
<td>26</td>
<td>−369</td>
<td>63</td>
</tr>
<tr>
<td>2008</td>
<td>15</td>
<td>24</td>
<td>2</td>
<td>−22</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>−475</td>
</tr>
</tbody>
</table>

*Projected.*
Table 7. Summary of Costs and Benefits for QuickRide (2002 Dollars)

<table>
<thead>
<tr>
<th>Benefit category</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Travel time savings</td>
<td>$2,360,000</td>
</tr>
<tr>
<td>Fuel savings</td>
<td>$33,700</td>
</tr>
<tr>
<td>Emissions savings</td>
<td>$-1,100</td>
</tr>
<tr>
<td>Costs</td>
<td></td>
</tr>
<tr>
<td>Start up costs</td>
<td>$477,900</td>
</tr>
<tr>
<td>Operations and maintenance</td>
<td>$1,010,700</td>
</tr>
<tr>
<td>Benefit cost ratio</td>
<td>1.61</td>
</tr>
</tbody>
</table>

QuickRide Costs

The costs of the QuickRide project included agency start up costs plus annual operation and maintenance costs. The $2 toll and $2.50 monthly enrollment fee were not included as they were simply transfers from the driver to the QuickRide agency. Additionally, the travel speed and level of service on the HOT lane were not degraded so previous users of the HOT lane did not experience additional travel costs due to the presence of QuickRide participants. Conversely, the limited number of QuickRide enrollees leaving the GPLs did not significantly impact travel on those lanes and therefore no benefits were calculated for GPL users.

The Texas Department of Transportation and Houston METRO supplied cost figures for QuickRide from 1997 to 2002. These cost figures included all costs incurred due to the QuickRide program over and above the HOV lane operations (the base case). Based on these figures, researchers attempted to separate start up costs and annual costs and arrived at the following cost estimates:

- Average monthly operation and maintenance costs: $8,263 (in 2002 dollars)
- Katy start up costs: $362,389 (in 1997 dollars)
- US 290 start up costs: $52,482 (in 2000 dollars)
- Total costs: $1,488,600 (in 2002 dollars)

QuickRide Summary

The total benefits of QuickRide over the 10 year period exceeded costs by 61% (see Table 7).

Conclusions

This analysis of QuickRide, one of the earliest operational variable pricing projects in the U.S., found that the incremental societal benefits exceeded costs. Similar results were found in a companion paper that investigated the corresponding benefits and costs for the SR-91 Express Lanes. The magnitudes of the differences in benefits and costs were dramatically different for the two projects, indicative of the relative size of the two projects and the number of travelers impacted. On SR-91, tens of thousands of travelers were impacted on a daily basis where QuickRide’s impact was limited to approximately 400 travelers per day. Interestingly, the benefit-cost ratios of the two projects were similar, both between 1.5 and 1.7. Although these ratios were similar for these two projects, other variable pricing projects are likely to yield different results.

The analysis also found that the majority of benefits were derived from travel time savings. The VOT was the key factor in determining total benefits. Although a great amount of research has been done to estimate VOT, the bulk of it has been through stated preference surveys, often analyzing different mode choices. More research is needed on VOT derived from operational toll projects, particularly ones where the toll varies by time of day. This will allow researchers to better quantify both the VTTTS and the benefits derived by travelers who gain the option of traveling congestion-free at their preferred time of day. This data may be derived from existing variable pricing projects and, in turn, help quantify the benefits of proposed future projects.

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