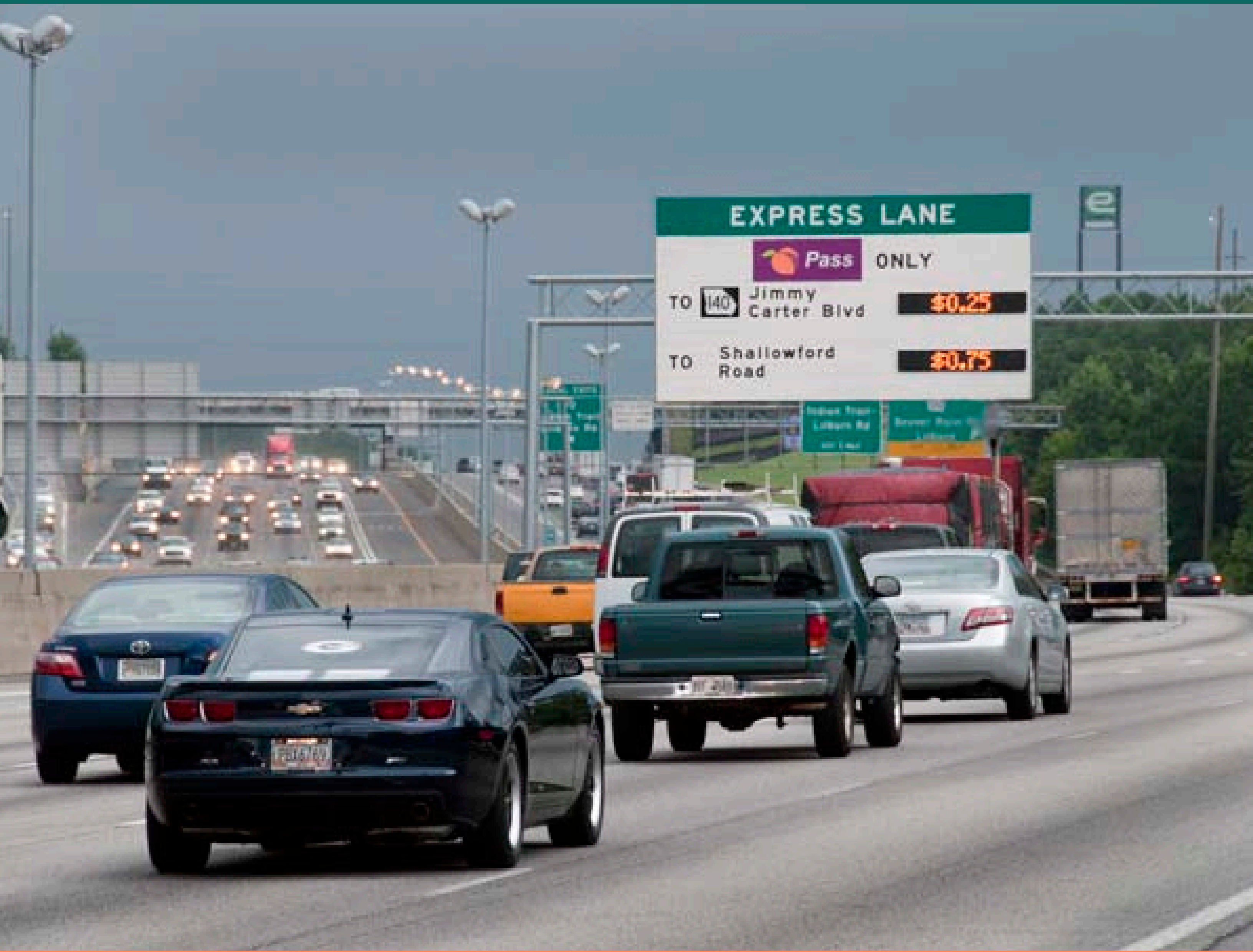
A Highway for All?

ECONOMIC USE PATTERNS FOR ATLANTA'S HOT LANES



A REPORT BY THE SOUTHERN ENVIRONMENTAL LAW CENTER

Southern Environmental Law Center

The Southern Environmental Law Center (SELC) is a regional nonprofit organization engaged in environmental advocacy, including promoting more sustainable transportation policies, in six southeastern states.

SELC's Atlanta office has long recognized transportation as one of the key issues affecting our metro region, from environmental impacts of various transportation options to the way transportation affects the very character of our community and its quality of life. SELC advocates for smart, environmentally beneficial, equitable transportation options through our law and policy work in Georgia and through the organization's blog on Atlanta transportation, JunctionATL.org.

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EXECUTIVE SUMMARY

Metro Atlanta's transportation plans are increasingly focused on managed lanes, like the High Occupancy Toll lanes on Interstate 85, as a key strategy for improving mobility in the region. Three other managed lane projects are in development and an update to the region's managed lane plan is underway. The transportation performance of these lanes has been scrutinized extensively but less analysis has been done on whether income plays a role in whether drivers choose to use the toll lanes. Social equity concerns have been raised that the so-called "Lexus Lanes" are used primarily by higher income drivers, but no one has examined data from Atlanta's High Occupancy Toll lanes to test this assertion.

This report examines transaction data for the Interstate 85 High Occupancy Toll lanes to determine whether a relationship exists between toll lane use and the economic profile of the toll lane users. Consistent with similar research from elsewhere in the country, this report finds a positive relationship between a ZIP code's median income and its frequency of toll lane use. However, the strength of this correlation suggests that income is not the only variable influencing the use of the lanes. Although the data available for this report and its scope are limited, its findings support the hypothesis that drivers' income and High Occupancy Toll lane use are linked. This report identifies where more comprehensive analysis is possible and suggests policy measures that can mitigate the inequitable effects of managed lanes.

INTRODUCTION

Facing congested highways and decreasing funding, transportation agencies around the country have increasingly turned to managed lanes as a strategy both to fund new highways and to improve the performance of these projects. Managed lanes use variable-priced tolls, alone or in combination with carpool requirements, to actively manage access. The variable-priced tolls rise and fall with demand to regulate the number of drivers using the lane and help the lane operate smoothly throughout the day. High Occupancy Toll (HOT) lanes are one type of managed lane that allow both toll-paying drivers and carpools to access the lane. HOT lane projects have been deployed around the country, including Denver, Minneapolis, Seattle, Miami, and Washington, DC.

U.S. Congestion Pricing Projects in Operation or Construction

Sources: *"Road Pricing Can Help Reduce Congestion, but Equity Concerns May Grow,"* Government Accountability Office, GAO-12-119 (Jan 12, 2012).

In 2007, Georgia's State Transportation Board adopted a resolution requiring all new highway lanes in metro Atlanta to be managed lanes. The Board also adopted a Managed Lane System Plan which identified dozens of potential managed lane projects for the region at an estimated cost of $16 billion. In October 2011, metro Atlanta opened its first managed lane project when the existing carpool lanes on Interstate 85 were converted to HOT lanes. Depending on demand, the one-way toll to drive the length of the I-85 HOT lanes has ranged from a few cents to over $7.00. Georgia is now considering a slate of additional managed lane projects, and the Georgia Department of Transportation is revising the Managed Lane System Plan with the goal of implementing additional projects.

HOT lanes and other managed lane projects have been criticized on equity grounds, reasoning that higher-income drivers are more likely to pay the toll required to use them, leading to the moniker "Lexus Lanes." Analysis of a managed lane project in California found that commuters with incomes greater than $100,000 were more than twice as likely to frequent the toll lane as commuters with incomes below $40,000.[1] Another HOT lane study found that "the wealthiest quartile receives travel-related benefits more than 17 times greater than the poorest quartile."[2] Managed lanes require public funding for their construction, leading critics to argue that the use of public dollars for such projects magnifies their inequity.

Three general approaches have been used to assess the equity impacts of managed lanes. The first and most common approach uses driver opinion and willingness-to-pay surveys to discern whether low-income drivers have different opinions of managed lanes than higher-income drivers. The second approach examines whether low-income drivers enroll in the managed lane tolling program or obtain toll transponders at differing rates than higher-income drivers. The third and least common approach examines actual data to determine whether managed lane use changes with income level. As a whole, these studies find that drivers of all income groups share similar opinions of the lanes, enroll in the tolling programs at comparable rates, and on occasion use the lanes.[3] However, the studies of actual use data find that low-income drivers use managed lanes less frequently than their higher-income counterparts.

To date, Georgia's consideration of these equity issues has focused on opinion surveys, enrollment rates, and transportation modeling.[4] Actual data from the I-85 HOT lane project is now available and the Federal Highway Administration previously committed to analyze the environmental justice impacts of the project. However, no such analysis of the project's equity impacts has been released to date.[5] Therefore, drawing on the methodology of previous equity studies, this report offers an initial examination of data from the I-85 HOT lanes to determine whether a relationship exists between income and use of these lanes.

METHODOLOGY & ANALYSIS

Transaction data for the I-85 HOT lanes was obtained from Georgia's State Road and Tollway Authority for a four-month period over the fall of 2012. This data included the date, duration, average speed, toll status, cost, and ZIP code for over 1.5 million HOT lane transactions. Additional information, including trip distance and toll cost per mile, was derived from this data. Population and median income data for the relevant ZIP codes was obtained from the U.S. Census Bureau's American Community Survey.

The data was then limited to focus on the transactions most relevant to the question of whether household income influences HOT lane use. All transactions that were untolled[6] or had incomplete information were excluded. Transactions with out-of-state ZIP codes or post office boxes were also removed. The ZIP codes have vastly different populations, so each ZIP code's HOT lane use was considered on a per capita basis to correct for these differences. A large number of ZIP codes contributed few transactions to the total, so all ZIP codes with fewer than 0.3 trips per capita[7] were removed to focus the analysis on the ZIP codes responsible for the large majority of HOT lane traffic. These parameters reduced the number of ZIP codes considered from over

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[1] *"State Route 91 Value Priced Express Lanes: Updated Observations,"* E. Sullivan, 81st Annual Transportation Research Board Meeting, Preprint Paper No. 02-2554. Washington, DC (2002).

[2] *"Are HOT Lanes a Hot Deal? The Potential Consequences of Converting HOV to HOT Lanes in Northern Virginia,"* E. Safirova, K. Gillingham, W. Harrington, and P. Nelson, Resources for the Future (May 2003).

[3] *"Road Pricing Can Help Reduce Congestion, but Equity Concerns May Grow,"* Report to the Subcommittee on Transportation, Housing, and Urban Development and Related Agencies, U.S. Government Accountability Office (January 2012).

[4] *"Technical Memorandum 9: Social Equity and Environmental Effects Evaluation"* Atlanta Regional Managed Lane System Plan, prepared for the Georgia Department of Transportation by HNTB Corporation (January 2010).

[5] "An annual performance survey will be conducted after the first year of operation to validate the conclusion that the proposed project would not have disproportionate adverse impacts to environmental justice populations. As part of this survey effort, an attempt will be made to gain data related to the income levels of the managed lane users." *"Environmental Assessment and Finding of No Significant Impact for Interstate 85 HOV to HOT Conversion Project,"* Federal Highway Administration (March 10, 2010).

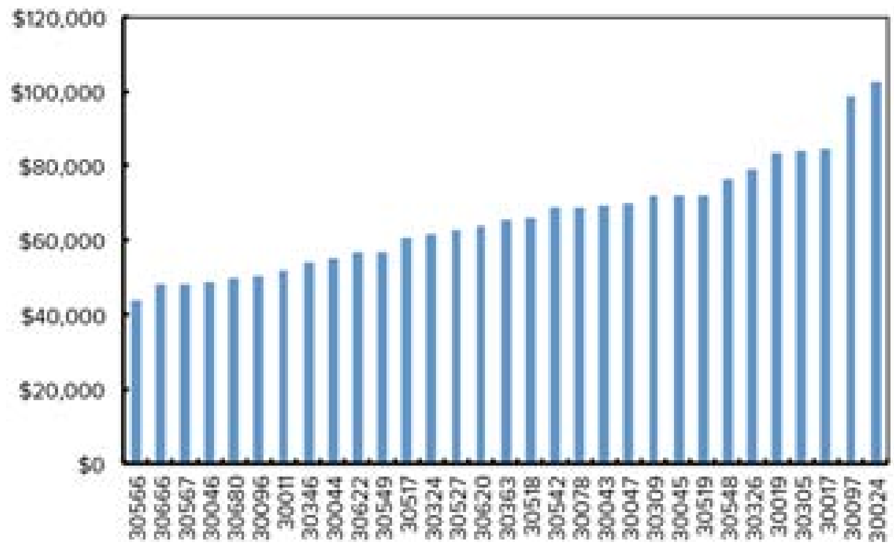
[6] The I-85 HOT lane's tolling policy allows three-person carpools, registered transit vehicles, motorcycles, and emergency vehicles to use the lanes without paying the toll.

[7] This threshold is equivalent to three hundred trips per thousand residents over the four-month period covered in this study.

1,000 to 31. Over 1 million HOT lane transactions satisfied these criteria and were included in the analysis. The HOT lane transactions were then aggregated by ZIP code and divided by population to derive each ZIP code's per capita use.

The highest median income ZIP code accounted for 129,921 transactions at a rate of 2.01 transactions per person; the lowest median income ZIP code accounted for 2,956 transactions at a rate of 0.38 transactions per person. The median incomes ranged from $43,770 to $102,635.

Distribution of ZIP Code Median Incomes



The Pearson Correlation Coefficient (*R*), a standard measure of the strength and direction of a linear relationship between two variables, was used to evaluate the relationship between median income and per capita use.[8] Additional analysis was then performed to determine whether this relationship was sensitive to the number of ZIP codes in the analysis, changes in toll prices, changes in the price per mile, and other variables. A more detailed discussion of the methodology is contained in the Appendix.

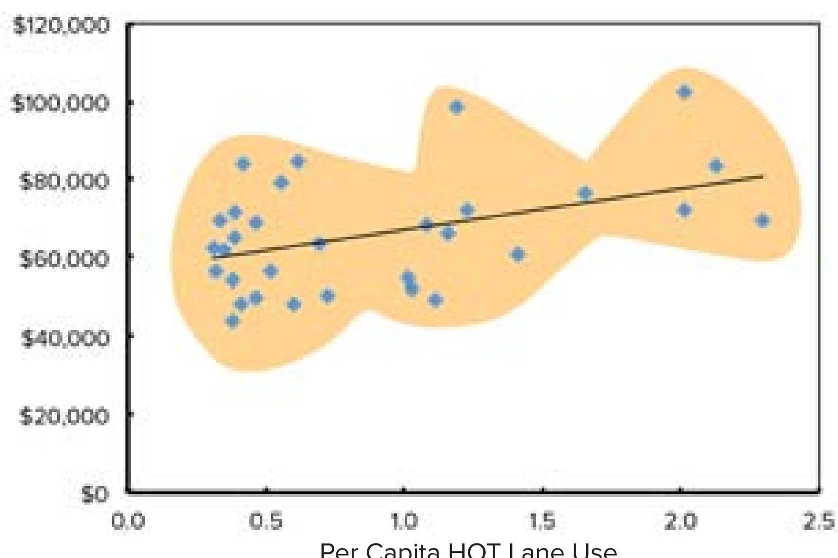
Graphic information systems software was used to illustrate and analyze spatial patterns in the data.

RESULTS

The analysis revealed a statistically significant correlation between median income and per capita HOT lane use for the ZIP codes examined. The Correlation Coefficient for this relationship was *R*=0.44.

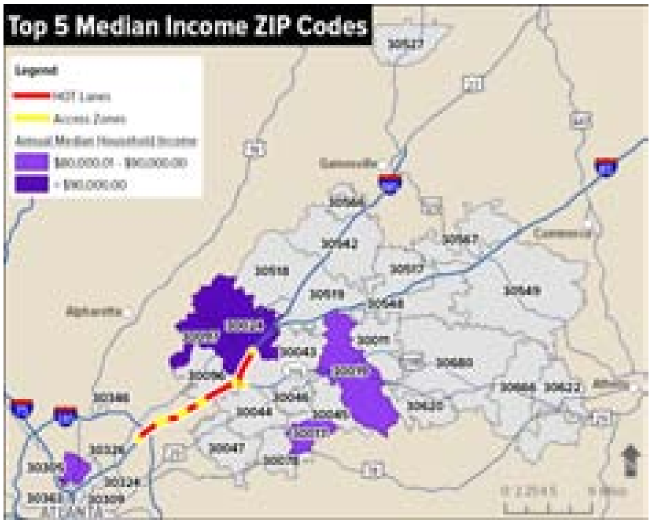
The Correlation Coefficient is widely used in the sciences to evaluate the strength of a linear relationship between two variables. A Correlation Coefficient of 1 indicates a perfect correlation and a value of 0 indicates no correlation. The Correlation Coefficient found here, *R*=0.44, is considered meaningful in the context of social science research. However, its moderate strength suggests that median income is not the only factor influencing the HOT lane use. The relative strength of the Correlation Coefficient found here is consistent with the results of other HOT lane analyses.[9]

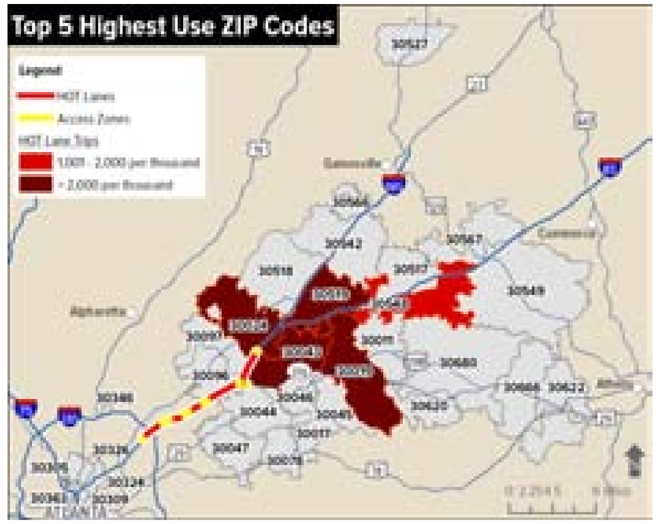
Median Income Versus Per Capita HOT Lane Use: Distribution of ZIP Code Data



[8] Two additional statistical measures, Probability (*p*-value) and Coefficient of Determination (R^2), were also calculated for this relationship and are discussed in more detail in the Appendix.

[9] "*Lexus Lanes or Corolla Lanes? Spatial Use and Equity Patterns on the I-394 MnPASS Lanes,*" T. Patterson and D. Levinson (March 2008) and *"State Route 91 Value Priced Express Lanes: Updated Observations,"* E. Sullivan, 81st Annual Transportation Research Board Meeting, Preprint Paper No. 02-2554. Washington, DC (2002).

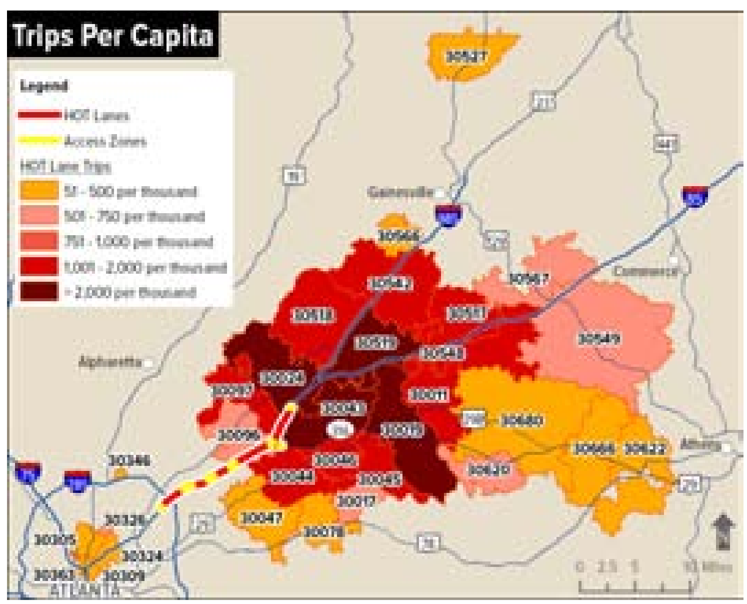




The relationship between income and HOT lane use was further examined across different trip cost and cost per mile ranges, and sensitivity analysis was performed to evaluate whether the use of 0.3 as a minimum level of per capita use influenced the results. HOT lane use was found to become less correlated with median income as trip price increased, but increasing cost per mile did not have the same effect. The results of these scenario analyses are discussed in more detail in the Appendix.

RECOMMENDATIONS

This report is limited in scope and could be refined in three important respects. First, the ZIP code-level data used here is the most detailed transaction information the State Road and Tollway Authority makes available to the public. Ideally, individual income and use patterns would be analyzed. But even in the absence of individual information, more detailed analysis could still be performed by mapping the user addresses and comparing the result against income data at the census tract or census block level. Second, a number of other variables likely to influence HOT lane use were not considered here, such as proximity to HOT lane entry points, likely destinations, availability of alternate routes and availability of transit service. A more comprehensive analysis using traffic modeling, geospatial analysis, and other tools could address some of these variables. Third, this report analyzes data from a four-month period during the fall of 2012. Analyzing all transaction data since the lanes were opened would both provide a larger dataset and reveal month-to-month trends in the use of these lanes.



In its March 2010 "*Environmental Assessment and Finding of No Significant Impact*," the Federal Highway Administration committed to conduct a comprehensive analysis of the social equity impacts of this project after its first year of operation. As of the date of this report, no such study has been made public. The federal and state transportation agencies should follow through on this commitment and conduct a comprehensive analysis of the I-85 HOT lanes consistent with the three recommendations outlined above.

Federal and state agencies should also pursue mitigation policies for the I-85 HOT lanes and future managed lane projects to better allocate the benefits of these projects across all income groups. To date, efforts to address equity concerns with the lanes have focused on payment systems, allowing drivers to pay the tolls without credit cards.[10] But this mitigation measure fails to address the underlying problem that the variable-priced toll is itself the source of inequity. There are a number of policies that can be implemented to better mitigate for the environmental justice effects of tolling for this and future managed lane projects.

Maximize Carpool Access

Before they were converted into HOT lanes, the managed lanes on I-85 were operated as carpool lanes. As part of this conversion, the occupancy requirement for high-occupancy vehicles was raised from two-persons to three. This change deters the formation of carpools and makes it more difficult for lower-income drivers to utilize the lanes via the untolled carpool option. Future toll lane proposals in the metro Atlanta region contemplate eliminating the high-occupancy option altogether. Allowing two-person carpools to utilize the region's managed lanes is sound policy both from an equity and a transportation performance perspective.

Limit State Funding

Equity concerns are lessened when the cost of a premium service is borne exclusively by those that elect to use it. But the cost of constructing and maintaining managed lanes greatly exceeds the revenue generated by their tolls, and the remaining cost is paid for with public funds collected from all Georgia taxpayers. As a result, drivers who cannot afford to use the lanes or choose not to do so are nonetheless paying for these projects. Capping the availability of non-toll, public funding for future managed lane projects will make them more equitable by limiting the subsidization of users by non-users.

Use Toll Revenue to Fund Parallel Transit Service

Transit vehicles use managed lanes free of charge, and managed lane supporters argue that low-income commuters can benefit from these projects by using transit. However, this argument assumes the existence and sufficiency of transit service in the managed lane corridor. Using a portion of toll revenues from the managed lanes to fund transit service in the corridor ensures that this untolled option exists. A number of states have adopted laws requiring toll lane revenues to be flexed to support parallel transit service as mitigation strategy, and Georgia should do the same.[11]

Provide Minimum Access for All Registered Users

Allowing all registered users limited access to the managed lane without charge could also ensure that all drivers receive a minimum benefit from the managed lanes irrespective of income. This minimum use could be accomplished by providing all users an annual account credit or allotting each user a certain number of managed lane trips free of charge. This approach would not only benefit users who are deterred from using the lanes for monetary reasons, but also users who choose not to use the lanes for philosophical reasons.

Given the substantial investment of public funds required to build them, the benefits of managed lanes projects must be available to Georgians of all income levels. The agencies charged with operating metro Atlanta's existing and future managed lane projects must take action to ensure that household income does not prevent low-income drivers from receiving the benefits of these projects. Adoption of mitigation measures such as those outlined above will help manage these lanes not only for congestion, but also for public benefit.

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[10] "*Northwest Corridor Project Final Environmental Impact Statement Reevaluation*," Federal Highway Administration and Georgia Department of Transportation (March 2013).

[11] R.C.W. § 47.66.090 (Washington); Fla. Stat. § 338.166 (Florida); Cal. Sts. & Hy. Code § 149.6(e)(3) (California); and Minn. Stat. § 160.93 Subd. 2a(b) and (c) (Minnesota).

APPENDIX

This appendix provides additional information, explanation, and analysis in support of the preceding report.

Data Acquisition

HOT lane transaction data for a four-month period over the fall of 2012 was obtained from the Georgia State Road and Tollway Authority (SRTA). Each transaction contained the following information: a unique transaction identification number, date, direction, entry and exit points, entry and exit time, trip duration, average speed, toll amount, and the ZIP code associated with the user's HOT lane transponder. More detailed information regarding the individual HOT lane users, specifically the account's street address, was requested from the SRTA but refused on grounds that the Georgia Open Records Act did not allow production of such information.

Simple arithmetic calculations were performed on this data to derive additional information. SRTA's trip duration data was converted into hours and multiplied by the average speed (miles per hour) to calculate the trip distance. Dividing the toll by the trip distance provided the trip's cost per mile. Population and median income data for each ZIP code was obtained from the U.S. Census Bureau's American Community Survey 5-year estimates (2007-2011). The number of transactions per ZIP code was divided by its population to calculate per capita HOT lane use. In total, the information utilized in this report was obtained from the following sources:

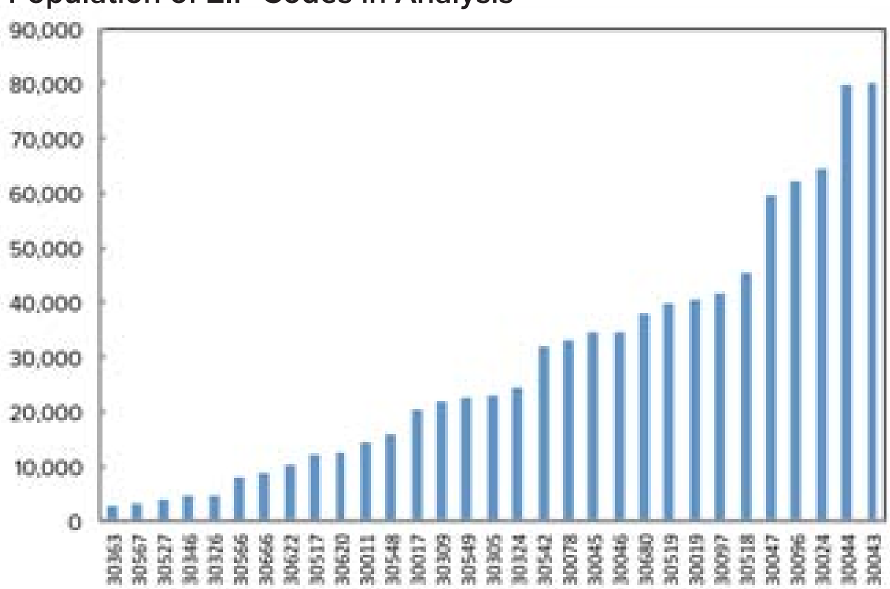
Data	Source
Transaction Identification Number	SRTA
ZIP Code	SRTA
Average Speed	SRTA
Trip Duration	SRTA
Trip Distance	Calculated
Trip Cost	SRTA
Toll Per Mile	Calculated
ZIP Code Population	Census
ZIP Code Median Income	Census
Transactions Per Capita	Calculated

Dataset Definition

The SRTA data included 1,645,396 discrete transactions. Of this data, 358,916 transactions were excluded because they involved untolled vehicles (such as three-person carpools, motorcycles, registered transit vehicles, or emergency vehicles) or because they had incomplete data. The remaining 1,286,480 transactions were advanced in the analysis.

The data included transactions from 1,061 separate ZIP codes. However, 596 of these ZIP codes (and 1.5% of the transactions) were located out of state or were associated with post office boxes. The location of these accounts raised

Population of ZIP Codes in Analysis

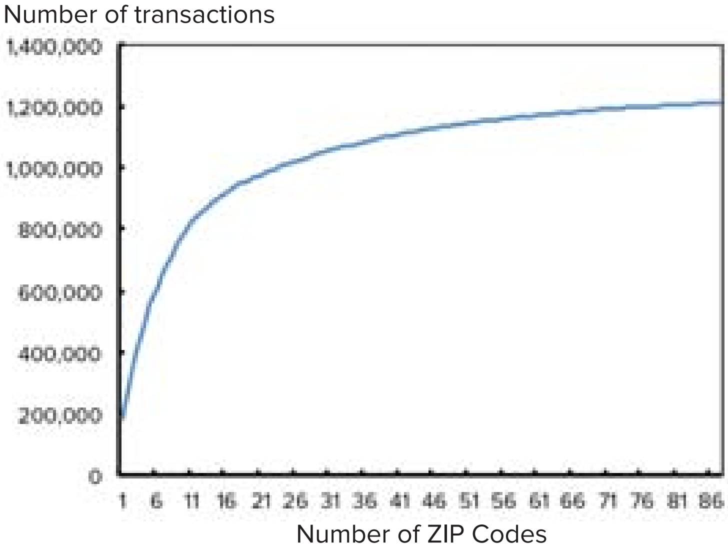


concerns that they might be business accounts, and the existence of a corporate subsidy might alter the influence of personal income on HOT lane use. Therefore, the transactions associated with post office boxes and out-of-state ZIP codes were eliminated from the analysis.

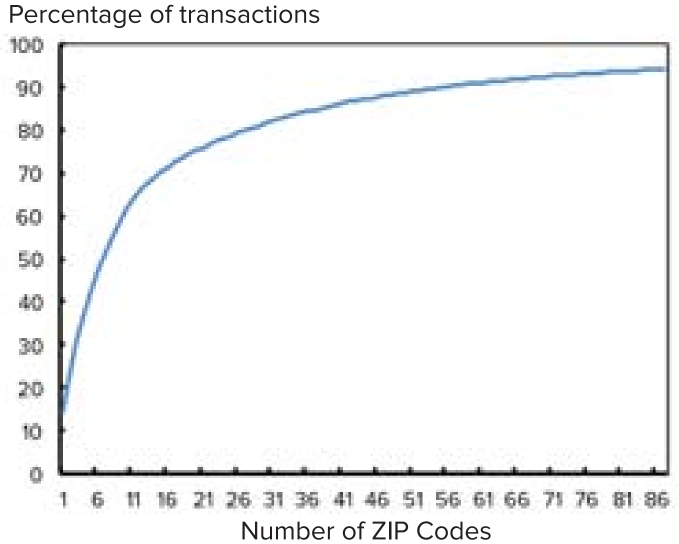
The ZIP codes also differ greatly in population, ranging from over 80,000 to fewer than 5,000 residents. Preliminary statistical analysis showed a very strong relationship between a ZIP code's transactions and its population (R=0.81; p=<0.0001). To correct for population differences, this report considers a ZIP code's HOT lane use on a per capita basis.

The vast majority of the 1.2 million transactions originated from a relatively small number of ZIP codes located around metro Atlanta, with 74% of the total transactions associated with 2% of the total ZIP codes. The remaining ZIP codes contributed a diminishing number of transactions to the overall data set.

Number of Transactions by Number of ZIP Codes



Percentage of Transactions by Number of ZIP Codes



To avoid weighting ZIP codes that contribute a small number of transactions equally with those that account for the majority of trips, this report excluded all ZIP codes that did not exceed a minimum rate of per capita use. The minimum rate of use selected was 0.3 transactions per capita, which equates to 300 transactions per 1,000 persons. Thirty-one ZIP codes exceeded this per capita minimum, accounting for 78% of the total transactions. As discussed in greater detail below, a sensitivity analysis was performed to ensure that the particular minimum level of use selected did not meaningfully alter the results.

Per Capita Use	ZIP Codes	Transactions	Percentage of transactions
2.00	4	480,392	37
1.50	5	506,617	39
1.00	13	836,516	65
0.50	19	918,580	71
0.30	31	1,011,258	79
0.25	35	1,037,871	81
0.10	61	1,157,142	90

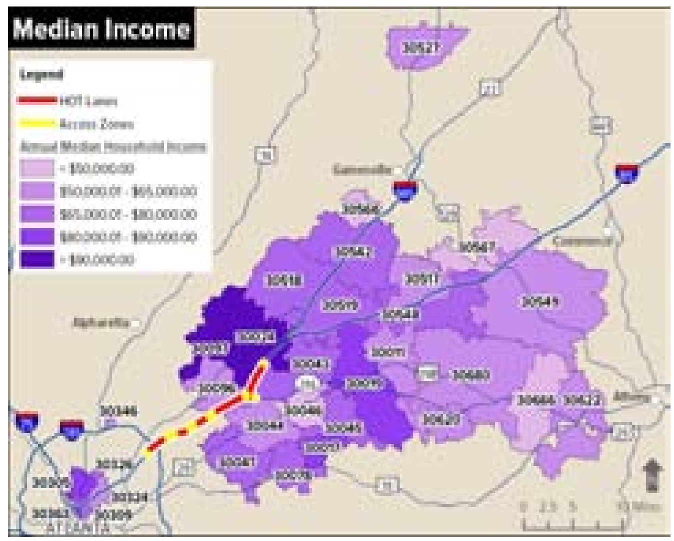
Role of Distance in HOT Lane Use

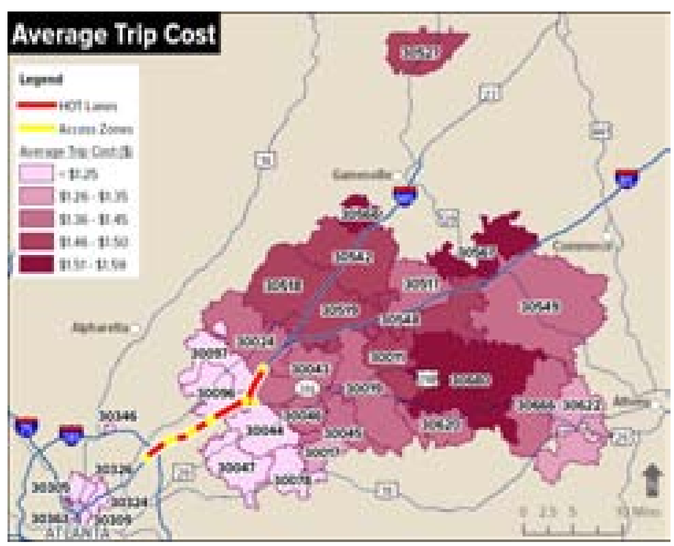
Other HOT lane use studies have concluded that trip distance plays a role in both the rates of HOT lane use and trip price.[12] Distance can influence HOT lane use in several ways. First, because HOT lane tolls are assessed based on the distance traveled, longer trips will incur larger tolls than shorter trips under otherwise comparable conditions. Second, the length of the trip is likely to differ depending on a ZIP code's geographic location and proximity to the terminal ends of the lane. Of the thirty-one ZIP codes in this analysis, the average length of the HOT lane trips ranged from 4.6 miles to 9.6 miles. Third, ZIP codes may differ in their ability to access the HOT lanes depending on their proximity to the entry/exit points. As a result, the relative cost and convenience of using HOT lanes may differ from between ZIP codes based solely on their geographic location.

Mapping the average trip cost of the thirty-one ZIP codes included in the analysis supports this relationship between price and location, as ZIP codes located farther from the city center generally had higher average trip prices than ZIP codes located closer to the city.

Distance also complicates the equity analysis due to geographic trends in median income. In this corridor, the ZIP codes with higher median income are generally located farther north and closer to the city center. Median income generally decreases as the ZIP codes move to the east and south away from the city center. This geographic trend in median income runs counter to the geographic trends in trip length and trip price. As a result, the more distant ZIP codes are likely to have longer and higher-priced trips but lower median income. Conversely, ZIP codes closer to the city center are likely to have shorter and lower-priced trips but higher median income.

To address distance as a confounding variable, the HOT lane use data was analyzed in two different cost scenarios to refine the relationship between cost and use. In the first scenario, income and use were examined across four different trip cost ranges: under $4.00, $4.01-5.00, $5.01-6.00, and over $6.00. In the second scenario, income and use were examined across three different cost per mile ranges: under $0.24, $0.25-0.34, and over $0.35. Cost per mile does not vary with distance, so this second scenario attempts to minimize the role of distance when analyzing the relationship between use and price.





[12] "*Lexus Lanes or Corolla Lanes? Spatial Use and Equity Patterns on the I-394 MnPASS Lanes,*" T. Patterson and D. Levinson (March 2008).

Results

Overall Analysis

The Pearson Correlation Coefficient (R), a standard measure of the strength and direction of a linear relationship between two variables, was used to evaluate the relationship between a ZIP code's median income and its HOT lane use. Probability, known as *p*-value, was also calculated for this relationship. The *p*-value provides evidence that the relationship between two variables reflects the hypothesis rather than random chance. The normally accepted standard for a significant *p*-value is less than 0.05, indicating a 5% likelihood that the results are a correlation due to random chance. The Coefficient of Determination (R^2), which illustrates how accurately a model fits the data, was also calculated for this relationship.

A statistically significant positive correlation was found between median income and per capita HOT lane use for the ZIP codes studied. The Correlation Coefficient (R=0.44) and *p*-value (p=0.01) suggest a moderately strong correlation, meaning the two variables are linked but other variables (such as distance) likely also play some role in a ZIP code's HOT lane use. The Coefficient of Determination found here, R^2=0.19, indicates that 19% of the variation in the use data can be explained by the ZIP codes' income levels.

The Correlation Coefficient was also calculated for the relationship between a ZIP code's income and its total number of transactions (rather than per capita use). This analysis produced a slightly weaker relationship (R=0.38; p=0.03; R^2=0.15). This comparison was performed to ensure that considering use on a per capita basis, rather than on the total number of transactions, did not produce meaningfully different results.

Income to Use Correlation Coefficients

	R	p	R^2
Income to Per Capita Use	0.44	0.01	0.19
Population to Number of Transactions	0.81	<0.0001	0.65
Income to Number of Transactions	0.38	0.03	0.15

Cost Scenario Analysis

To address distance and cost as potentially confounding variables, the same HOT lane data was divided according to different trip price and cost per mile ranges. The relationship between income and HOT lane use was then considered for each of these ranges to determine whether they changed as price increased, and whether driver behavior within these ranges differed from the behavior as a whole.

Trip Cost Scenario

In the first scenario, HOT lane transactions were divided into four ranges based on the total trip cost: less than \$4, \$4-4.99, \$5-5.99, and greater than \$6. The distribution of trips was heavily weighted toward the lowest cost range, with 94% of the total trips in the less than \$4 range. The distribution decreased further as the trips became more expensive, with less than 0.3% of the trips in the greater than \$6 range. Although this distribution of trips is not ideal, it nonetheless provides useful information on the degree to which increasing trip price alters user behavior.

Price Distribution of Trips for ZIP Codes with Per Capita Use >0.3

	Trips	Percent
Less than \$4.00	950,050	94.0
\$4.00-4.99	34,525	3.4
\$5.00-5.99	23,042	2.3
Greater than \$6.00	3,441	0.3

The transaction data in each range was analyzed to determine the correlation between a ZIP's code's median income and its per capita HOT lane use within that range. The analysis showed a statistically significant positive relationship between increases in a ZIP code's income and its HOT lane use for trips under \$4 and between \$5-5.99. For the other two ranges the *p*-value exceeded the acceptable limit of 0.05, so the results are not deemed significant.[13]

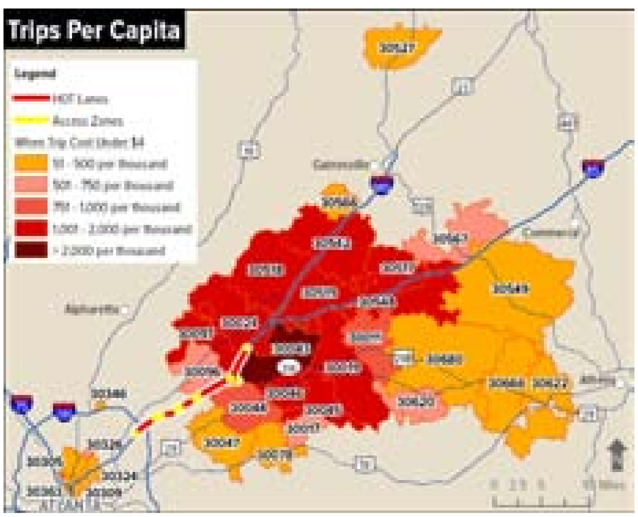
[13] A *p*-value above 0.05 suggests an unacceptable likelihood that the correlation between the variables is due to chance. It is noteworthy that the two ranges with unacceptable *p*-values were also the two ranges with the lowest Correlation Coefficients (R) found anywhere in the analysis. The increased level of uncertainty about these two results suggests that the relationship could be either weaker or stronger than what the Correlation Coefficient suggests. A stronger Correlation Coefficient would be more in line with the other ranges and the analysis as a whole.

Given that the vast majority of transactions analyzed fall within the under-$4 range, it is not surprising that the Correlation Coefficient (0.44), Probability (0.01), and Coefficient of Determination (0.20) values for this range are very similar to those for the analysis as a whole. The Correlation Coefficients for the high-priced ranges were generally lower, suggesting that the relationship between income and use weakened as trip price increased. Other studies have suggested that HOT lane demand becomes increasingly inelastic as price increases,[14] a hypothesis consistent with the results of this report.

Correlation Between HOT Lane Use and Average ZIP Code Income Across Total Cost Ranges

	R	*p*	R^2
Income and Per Capita Use	0.44	0.01	0.19
Income to Per Capita Use for Trips:			
Less than $4.00	0.44	0.01	0.20
$4.00-4.99	0.28	0.10	0.09
$5.00-5.99	0.36	0.05	0.13
Over $6.00	0.17	0.37	0.03

The maps on the next page illustrate the intensity and geographic distribution of HOT lane use under the four trip cost ranges.



[14] *"Lexus Lanes or Corolla Lanes? Spatial Use and Equity Patterns on the I-394 MnPASS Lanes,"* T. Patterson and D. Levinson (March 2008).

Cost Per Mile Scenario

In the second scenario, the HOT transactions were divided into three ranges based on the trip's average cost per mile: less than $0.24, $0.25-0.34, and greater than $0.35. The distribution was again heavily weighted toward the lower-cost trips but was more balanced than in the first scenario.

All three ranges had Correlation Coefficients comparable in strength to the overall results and *p*-values within the accepted limit. The range reflecting the vast majority of trips—under $0.24 per mile—was almost precisely in line with the overall results. For the additional ranges, the strength of the Correlation Coefficient weakened slightly and the *p*-values increased. However, the lack of significant differences between the three ranges suggests that small changes in the cost per mile may not have a meaningful impact on driver behavior.

Toll Per Mile Distribution for ZIP Codes with Per Capita Use > 0.3

	Trips	Percent
Less Than $0.24	767,107	76
$0.25-0.34	141,585	14
Greater than $0.35	102,524	10

Correlations Between Per Capita Use and Median Income Across Per Mile Ranges

	R	*p*	R^2
Income and Use for All Trips	0.44	0.01	0.19
Income to Use for Trips			
Under $0.24/Mile	0.45	0.01	0.20
Between $0.25-0.34/Mile	0.36	0.05	0.13
Over $0.35+/Mile	0.40	0.02	0.16

Comparing the two scenarios, one noteworthy difference is in the strength of the correlation for the highest-price trips. The Correlation Coefficient for trips with the highest cost per mile (over $0.35) was comparable to the results overall (*R*=0.40 versus *R*=0.44). However, the Correlation Coefficient for trips with the highest total cost (over $6) was roughly half as strong as in the overall analysis (*R*=0.17 versus *R*=0.44). In other words, increases in the overall trip cost weakened the relationship between income and use, but increases in price per mile did not have the same effect. This may suggest that driver behavior is influenced more by the total cost of the trip than by small changes in the per mile cost.

Sensitivity Analysis

Two important methodology decisions were made in this report. First, the report defines a ZIP code's HOT lane use in per capita terms rather than basing it on the total number of transactions. Second, the analysis in this report excludes the ZIP codes that did not contribute more than a minimum number of transactions per capita. To ensure that these decisions did not significantly alter the results, a limited sensitivity analysis was performed to evaluate the effect of these decisions.

Per Capita Use Versus Total Transactions

To correct for the large differences in ZIP code populations, this report defined a ZIP code's HOT lane use as the number of transactions per capita rather than its total transactions. To ensure that this definition did not meaningfully change the results, Correlation Coefficients were calculated for the relationship between median income and total number of transactions for each of the scenarios in this analysis.

Both overall and throughout the various price ranges, the relationship between HOT lane use and income remained relatively consistent whether use was defined by total transactions or transactions per capita. The Correlation Coefficient was slightly lower when use was defined based on total transactions (*R*=0.38) rather than per capita (*R*=0.44).

Correlation Coefficients Based on Total Transactions Versus Per Capita Use

	Transactions	Per Capita
Total	0.38	0.44
Total Trip Cost		
Less than $4.00	0.38	0.44
$4.00-4.99	0.35	0.28
$5.00-5.99	0.39	0.36
Greater than $6.00	0.27	0.17
Per Mile Cost		
Less than $0.24	0.39	0.45
$0.25-$0.34	0.34	0.36
Greater than $0.35	0.38	0.40

Across the two price scenarios, the transactional standard produced higher *R*-values for the total trip cost scenarios but slightly lower *R*-values for the cost per mile scenario. Based on this analysis, defining use in per capita terms rather than total transactions did not significantly alter the results.

Per Capita Minimum Used

This report excludes all ZIP codes that did not exceed a minimum threshold of transactions per capita. Setting this threshold required striking a balance between inclusion and exclusion: including more ZIP codes would increase the sample size of ZIP codes and transactions, thereby making the analysis more comprehensive and helping to obtain valid *p*-values. But including low-use ZIP codes risks adding noise to the analysis, and the transaction data associated with low-use ZIP codes is more at risk of being skewed by individual

	Per Capita >0.25			Per Capita > 0.3			Per Capita > 0.35			Per Capita > 0.5		
	n=35; % = 81			n = 31; % = 79			n = 28; % = 77			n = 19; % = 71		
	R	*p*	R^2	*R*	*p*	R^2	*R*	*p*	R^2	*R*	*p*	R^2
Income and Intensity	0.39	0.02	0.16	0.44	0.01	0.19	0.44	0.02	0.19	0.43	0.07	0.18
Population and Number of Transactions	0.80	<.0001	0.64	0.81	<.0001	0.65	0.85	<.0001	0.72	0.85	<.0001	0.72
Income and Number of Transactions	0.36	0.03	0.13	0.38	0.03	0.15	0.37	0.05	0.14	0.34	0.16	0.11
Income to Per Capita Use Under $4.00	0.40	0.02	0.16	0.44	0.01	0.20	0.45	0.02	0.20	0.43	0.06	0.19
Income to Per Capita Use $4.00-5.00	0.27	0.11	0.07	0.30	0.10	0.09	0.30	0.12	0.09	0.30	0.12	0.09
Income to Per Capita Use $5.00-6.00	0.32	0.06	0.10	0.36	0.05	0.13	0.36	0.06	0.13	0.41	0.08	0.17
Income to Per Capita Use Over $6.00	0.16	0.36	0.03	0.17	0.37	0.03	0.17	0.40	0.03	0.13	0.59	0.02
Income to Per Capita Use Under $0.24	0.41	0.01	0.17	0.45	0.01	0.20	0.46	0.01	0.21	0.41	0.08	0.17
Income to Per Capita Use $0.25-0.34	0.31	0.07	0.10	0.36	0.05	0.13	0.36	0.06	0.13	0.37	0.12	0.14
Income to Per Capita Use$0.35+	0.35	0.04	0.12	0.40	0.02	0.16	0.40	0.04	0.16	0.44	0.06	0.19

Per capita = per capita use minimum; n = the number of ZIP codes included; and % = the percentage of the total number of transactions.

behavior.[15] The threshold used in this report, 0.3 transactions per capita, attempts to strike a balance between including the most data and maintaining its reliability.

To ensure that the particular threshold selected did not alter the results of the report, a sensitivity analysis was performed comparing the results under the 0.3 minimum to the results under different potential per capita minimums. The results of this analysis are contained in the preceding table.

The Correlation Coefficients and the *p*-values change slightly across the various per capita minimums examined, a function of the differing numbers of ZIP codes, transactions, and the actual data included in the analysis. However, the general trends held true across the different thresholds with a statistically significant relationship between a ZIP code's median income and its per capita HOT lane use in two of the three additional scenarios examined. The fourth scenario had a comparable *R*-value but had a *p*-value slightly in excess of acceptable levels (p=0.07). This result occurred for the highest threshold, 0.5 trips per capita, and likely reflects the smaller number of ZIP codes considered in that analysis. It does not appear that the per capita minimum of 0.3 transactions meaningfully altered the results.

LITERATURE

"Are HOT Lanes a Hot Deal? The Potential Consequences of Converting HOV to HOT Lanes in Northern Virginia," E. Safirova, K. Gillingham, W. Harrington, and P. Nelson, Resources for the Future (May 2003).

"Assessing the Equity Implications of HOT Lanes," A. Weinstein and G. Sciara , prepared for the Santa Clara Valley Transportation Authority (November 2004).

"Continuation Study to Evaluate the Impacts of the SR 91 Value-Priced Express Lanes - Final Report," E. Sullivan, prepared for the California Department of Transportation by California Polytechnic State University (December 2000).

"High Occupancy Toll Lanes: Potential for Implementation in the Atlanta Region," Atlanta High Occupancy Toll Lanes Study Final Report, prepared for the State Road and Tollway Authority by Parsons Brinckerhoff (April 1, 2005).

"Income-Based Equity Impacts of Congestion Pricing: A Primer," Federal Highway Administration (December 2008).

"Lexus Lanes or Corolla Lanes? Spatial Use and Equity Patterns on the I-394 MnPASS Lanes," T. Patterson and D. Levinson (March 2008).

"Road Pricing Can Help Reduce Congestion, but Equity Concerns May Grow," Report to the Subcommittee on Transportation, Housing, and Urban Development and Related Agencies, U.S. Government Accountability Office (January 2012).

"State Route 91 Value Priced Express Lanes: Updated Observations," E. Sullivan, 81st Annual Transportation Research Board Meeting, Preprint Paper No. 02-2554 (2002).

"Technical Memorandum 9: Social Equity and Environmental Effects Evaluation," Atlanta Regional Managed Lane System Plan, prepared for the Georgia Department of Transportation by HNTB Corporation (January 2010).

[15] Some of the ZIP codes were associated with fewer than 2,500 transactions. A single individual using the HOT lanes for a daily work commute over the four-month period would incur 160 transactions.

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