Exploring the Equity Impacts of Two Road Pricing Implementations Using a Traveler Behavior Panel Survey:

Full Facility Pricing on SR 520 in Seattle and the I-85 HOV-2 to HOT-3 Conversion in Atlanta

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14. ABSTRACT
This paper reports survey findings on the equity impacts of variable tolling programs implemented on SR 520 in Seattle (Urban Partnership Agreement) and on I-85 in Atlanta(Congestion Reduction Demonstration Program). The analysis utilizes data from panel surveys administered in Seattle and Atlanta, in which all adult members of sampled households were asked to complete surveys both before and after tolling. The analysis focuses on three types of equity impacts: income, geographic and modal. Income equity impacts were greater in Seattle, compared to Atlanta, as were geographic equity impacts. In Atlanta, modal equity, as measured through impacts to carpoolers, was a greater concern. In conclusion, the type and intensity of the equity impacts differed across the two sites as a result of the differences in the design of the pricing strategy as well as differences in regional context.

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Abstract

This paper reports findings on the equity impacts of recent variable tolling on the SR 520 bridge in Seattle and the HOV-2+ to HOT-3+ conversion on I-85 northeast of Atlanta. The analysis utilizes data from a traveler behavior survey conducted in both locations before and after the implementation of tolling (Wave 1 and Wave 2, respectively). All members of sampled households were asked to fill out a two-day travel diary and respond to questions about their typical travel in the corridor as well as their attitudes about tolling and travel.

The analysis focused on three types of equity: income, geographic and modal. In Seattle, lower-income individuals were much more likely to shift off of SR 520 and more likely to choose not to make a trip than higher-income users, suggesting that lost mobility may be a larger equity concern than the regressivity of the toll payment. Changes in traveler behavior varied less by income in Atlanta, though income was still a significant predictor of Peach Pass ownership. Users of I-90 in Seattle were overall less pleased with their commute in Wave 2, while SR 520 users were more satisfied, suggesting geographic inequity. In terms of modal equity, two person carpools, for the most part, shifted out of the Express Lanes and into the general purpose lanes, as the large majority of trips in the Express Lanes were solo drivers. Wave 1 HOV-2 users were significantly less satisfied with their Wave 2 I-85 trips, whereas the reverse was true for Express Lane users; they were significantly more satisfied in Wave 2 compared to Wave 1.

Introduction

Congestion pricing is a traffic demand management tool that seeks to improve the overall efficiency of the system by redistributing demand. However, by imposing toll costs on road users, road pricing raises concerns that users will be impacted differently. In particular, research has focused on outcome differences along three dimensions: geography, mode of transportation, and income. As with any change in the transportation network, there is the potential for inequity based on geography, depending on one's home or work location and experience of either a more free-flowing commute or one that absorbs some of the displaced trips from the priced route. There is also the potential for inequity between modes, if the improvement benefits solo drivers far more than carpoolers or transit riders, or vice versa. The aspect of equity raised most frequently with road pricing than with other congestion management practices, however, is income equity. Market-based solutions like road pricing introduce concerns about income equality and access. Pricing has the potential to deny access to the roadway to individuals based on their ability to pay, reducing mobility and quality of life for lower-income individuals unless successful mitigation measures are implemented.

The Urban Partnership Agreement (UPA) and Congestion Reduction Demonstration (CRD) Travel Behavior Survey data provide one of the first opportunities to assess the equity impacts of congestion pricing using actual before and after traveler behavior and opinion data. The survey was administered at one UPA project site, the SR 520 Evergreen Point Bridge across Lake Washington and one CRD site, I-85 in the northeast of metro Atlanta.

The SR 520 bridge was the first conversion of a free route (formerly a tolled bridge) into a fully priced facility, with the purpose of generating revenue to fund the replacement of the bridge. Toll collection is fully automated; vehicles without an electronic toll transponder (the Good to Go Pass) are identified using license plate recognition (Pay-by-Plate) and billed by mail. SR 520 tolls vary by time of day up to a maximum (in 2012) of $3.50 each way during peak hours, or $5 for non-transponder payments. A nearby parallel facility, Interstate 90, remains as a toll-free alternative across Lake Washington. An arterial, SR 522, runs around the northern end of the lake and can also be used an alternative to SR 520. Tolling was accompanied by investments in public transit and traffic management technologies and by efforts to promote telecommuting.

The Atlanta CRD project involved the conversion of an existing high occupancy vehicle (HOV-2) lane to a dynamically priced high occupancy toll (HOT-3) lane (also called "Express lanes"), combined with an increase in the occupancy requirement from 2+ to 3+. This HOV-2 to HOT-3 conversion was implemented along a 16 mile stretch of I-85 in northeast Atlanta, from I-285 in DeKalb County to Old Peachtree Road in Gwinnett County. The Express Lanes operate continuously for one lane in both the northbound and southbound directions, separated from the general purpose lanes by a double white striped buffer (no physical barrier exists). The Express Lanes operate with seven entry and exit points in the northbound direction as well as in the southbound direction, and toll rates are displayed at each entry point on changeable message signs. Tolling occurs 24 hours a day and seven days a week, and ranges from .01 cents to 90 cents per mile, based on demand in the Express Lanes.

Another key element of the CRD project is the requirement that **all** users must have a Peach Pass transponder to access the Express Lanes. Prior to traveling in the Express Lanes, users must register in either toll mode status (if a single occupant or two occupants in the vehicle) or non-toll mode status (if three or more occupants, motorcycle, or alternative fuel vehicle). Other strategies pursued as part of the CRD project include transit service enhancements, the deployment of ITS technologies (e.g., dynamic message signs, automated enforcement), and transportation demand strategies to encourage carpooling.

About the Survey

The Travel Behavior Survey is a two-stage panel survey, comprised of a sample of peak period corridor users in both Seattle and Atlanta. The sample was recruited before the implementation of pricing using a combination of license plate capture and transit intercepts. Each member of the sampled household was asked to fill out a trip diary for a two-day period before tolling began (Wave 1) and then again after tolling was implemented (Wave 2), as well as answer a series of attitudinal questions about tolling and travel in the region in general. For further information about the sample and overall survey results see the full reports submitted to the Federal Highway Administration[1].

The survey sample is representative of peak-hour commuters on the priced corridors, not of the larger region as a whole. Due to the sampling method, the sample has a greater share of employed commuters, with correspondingly higher incomes and greater representation from the middle age brackets. In addition, analysis is limited to just those households where all members completed the entire diary in both waves, a total of 2, 063 households comprising 3,698 people in Seattle and 1,655 households in Atlanta comprising 3,126 people. Larger households are slightly under-represented compared to the initial respondent sample.

Literature Review

Existing research on equity and road pricing has primarily focused on defining equity as it relates to transportation and then using case study examples to outline ways to mitigate or avoid inequality. In his 2009 review, David Levinson followed a similar template in analyzing the literature. Levinson found that "within road pricing there are three decisions that affect equity: allocating the burden of charges, spending the revenue, and distributing the externalities (Langmyhr, 1997). Road pricing also affects the amount and type of mobility that is subsequently consumed" (Levinson, 2010). Hence, the design of the pricing system, including how the accumulated revenue is used (e.g., to reduce taxes, to subsidize public transportation, or for another purpose) has significant implications for equity. In some cases the equity implications are clear and in others they are more obscure.

Levinson goes on to describe two overarching forms of equity:

- "Opportunity, or process, equity: the extent to which there is fair access to the planning and decision-making process (Fairness).
- Outcome, or result, equity: the extent to which consequences of a decision are considered just (Justice)" (Levinson, 2010).

This paper only addresses outcome equity, as opportunity/process equity issues are outside the scope of the traveler survey. Within outcome equity, Levinson describes several dimensions for which equity can be quantified, two of which will be addressed in this paper:

- Vertical equity—the extent to which members of different classes are treated similarly

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[1] Peirce, S., et al. "Effects of Full-Facility Variable Tolling on Traveler Behavior: Evidence from a Panel Study of the SR 520 Corridor in Seattle, Washington," *Transportation Research Record: Journal of the Transportation Research Board, No. 2345,* Transportation Research Board of the National Academies, Washington, D.C., 2013, pp. 74–82. Petrella, M., et al. "Effects of an HOV-2 to HOT-3 Conversion on Traveler Behavior: Evidence from a Panel Study of the I-85 Corridor in Atlanta," Final Report submitted to Federal Highway Administration, April, 2014.

- Spatial, or territorial, equity—the extent to which benefits and costs are distributed equally over space (Viegas, 2001) [2]

Along with this range of equity impacts, Levinson identified transportation- related externalities. Specifically, there are mobility externalities which arise because transportation projects often benefit some parties but worsen conditions for others. This issue most often manifests itself through inter-modal mobility externalities (Levinson, 2010). In the case of the SR 520 bridge project, mobility externalities are pertinent based on the multiple routes impacted by the project. In Atlanta, there is the possibility that former HOV-2 users will lose the mobility benefits they once enjoyed when they are no longer able to use the Express Lanes for free.

Along the lines of externalities, transportation equity research has emerged as a subset of the broader issue of environmental justice. According to Forkenbrock and Schweitzer, environmental justice can be defined as:

> Concerned with a variety of public policy efforts to ensure that the adverse human health or environmental effects of governmental activities do not fall disproportionately upon minority populations and low-income populations. In the realm of transportation, environmental justice requires that transportation system changes, such as road improvements, be studied carefully to identify the nature, extent, and incidence of probable consequences, both favorable and adverse. (Forkenbrock, 1999)

The environmental justice community has begun to specifically explore the benefits and burdens of congestion pricing as they relate to income equity (Kuehn, 2009; Ungemah, 2007).

As the number of operating projects using road pricing has increased, there has been an increase in demographic studies comparing users and non-users after the implementation of tolling. These studies include Burris and Hannay 2003, Sullivan 2000, Supernak et al. 2002, and Patterson and Levinson 2008. The latter two studies were conducted solely on high occupancy toll (HOT) and express lanes running parallel to free general purpose lanes, as opposed to fully priced facilities. These studies have generally found that some low-income motorists continue to use the priced lanes and that equity concerns decrease as users gain experience with the tolled road. However, there is also evidence that income is a significant predictor of transponder ownership and lane usage. Patterson and Levinson controlled for residential location and found that while income did not predict the number of trips individuals took, it was significant for MnPass ownership and distance travelled (Patterson 2008). This finding is corroborated by Emily Parkany who found that barriers to transponder ownership, such as high minimum balances and required credit card accounts, existed for low-income individuals (Parkany, 2005).

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[2] Other dimensions of equity include horizontal equity, longitudinal, generational, or temporal equity, market equity and social equity.

The key theme noted in the literature is the presence of indirect impacts and effects beyond the direct count of trips taken and tolls paid. Asha Weinstein and Gian-Claudia Sciara noted that the magnitude of equity impacts is correlated with schedule flexibility (Weinstein, 2004). Lisa Schweitzer identified concerns of reduced social inclusion as a result of higher mobility costs (Schweitzer, 2009), drawing on an earlier paper by Georgina Santos and Laurent Rojey (Santos, 2004). Both Weinstein and Sciara and Santos and Rajoy conclude that pricing as a concept cannot be deemed equitable or inequitable; the equity of the proposal depends on the context in which it is implemented.

The equity impacts of road pricing have been a concern for researchers and policymakers as the adoption of pricing has increased worldwide. A recent GAO report on congestion pricing, "Road Pricing Can Help, but Equity Concerns May Grow" (GAO, 2012), directly addressed the traffic diversion and geographic equity concerns associated with the SR 520 bridge. The Federal Highway Administration also released a primer on "Income-Based Equity Impacts of Congestion Pricing," which summarizes existing research and provides guidance for decision-makers on reducing impacts and ensuring that equity concerns do not derail projects (FHWA, 2008). The report concluded that while high-income motorists in the United States do use the priced lanes more often, the lanes are used to some degree by all income groups based on the benefit of providing a reliably timed route when absolutely needed.

Analytic Approach

This paper will begin by highlighting key baseline conditions using panel survey data and secondary information from the American Community Survey and the U.S. Census, summarizing 1) areas of high and low income within the corridor and 2) household trip profiles before tolling began. The analysis will focus on how changes in travel behavior in response to pricing differed by income, geography, and mode.

Income

For the analysis, income is normalized to percent of poverty level by household size and composition. The Census Bureau publishes a set of poverty thresholds each year used in developing estimates of poverty. The thresholds represent the income level at which a household cannot provide the food, shelter, and clothing needed to preserve health and are adjusted based on the Consumer Price Index. The threshold varies based on household size and composition; higher for smaller households with fewer children and lower in larger households with fewer adults. The threshold does not vary with geography.[3] Normalizing income with respect to the poverty threshold better reflects the household's purchasing power by accounting for household size and composition. A single parent with three children making $100,000 has a lower disposable income than a two-adult, no children household with the same income.

[3] The Census also varies the threshold by age, with older adults (65+) having a slightly lower threshold as well. The age variation was not captured in the normalization due to data complexities, but the difference is small relative to the error introduced by taking the midpoint of the income brackets.

To generate income data, the survey collected income information by asking respondents to select one of ten income brackets (a “no response” option was also included). To normalize to the poverty level, the midpoint of each bracket is assigned to all households selecting it. That number is then divided by the poverty threshold for households containing the same number of adults and children as the responding household. For the analysis, households are grouped into four income groups as follows:

- those making below the poverty threshold to three times the poverty threshold,
- those making three to five times the poverty threshold,
- those making five to ten times the poverty threshold, and
- those making over ten times the threshold.

The resulting groups can be seen in Tables 1 and 2 below.[4] In tables throughout the remainder of the paper, comparisons are generally presented by income group (1 through 4), with reference to the mean income of households in the group to provide a more concrete reference point.

Table 1: Seattle Income Groupings

	Poverty Level	Year 2 Income Range	Mean Year 2 Income	Year 1 Trips	Year 2 Trips	Individuals	Households
Income Group 1	Below poverty level - 3 times poverty level	$0 - $99,999	$37,399	2,183	1,750	302	174
Income Group 2	3 – 5 times poverty level	$35,000 - $149,999	$68,666	4,067	3,520	547	311
Income Group 3	5-10 times poverty level	$50,000 - $250,000 +	$117,037	11,959	10,025	1548	901
Income Group 4	More than 10 times poverty level	$100,000 - $250,000 +	$197,188	5,230	4,427	691	400
Total			**$118,806**	**27,217**	**23,055**	**3585**	**2058**

[4] Tables include only those individuals and households that made at least one trip in at least one wave and reported their household income in Wave 2. We had hoped to analyze respondents below the poverty level as a separate group; however, there were too few cases for analysis.

Table 2: Atlanta Income Groupings

Income Group	Poverty Level	Year 2 Income Range	Mean Year 2 Income	Year 1 Trips	Year 2 Trips	Individuals	Households
Income Group 1	Below poverty level – 3 times poverty level	$0 - $99,999	$43,675	2,583	2,116	413	230
Income Group 2	3 – 5 times poverty level	$35,000 - $149,999	$75,440	4,545	3,883	697	381
Income Group 3	5-10 times poverty level	$50,000 - $250,000 +	$113,337	7,602	6,406	1158	657
Income Group 4	More than 10 times poverty level	$100,000 - $250,000 +	$181,897	1,427	1,129	232	145
Total			**$98,083**	**18,763**	**15,704**	**2920**	**1651**

In both Seattle and Atlanta, the mean household income for the sample was relatively high ($118, 806 and $98,803, respectively), largely due to the fact that peak hour corridor users (who tend to be employed) were sampled. Regular SR 520 and I-85 users had even higher average incomes, relative to the total sample ($140,000 in Seattle and $100,135 in Atlanta).

In both Seattle and Atlanta, the lowest income group had a disproportionate number of students, those employed part-time, and those not currently employed. In Seattle, this group also had a slightly higher proportion of retirees. In Seattle, 40% of Income Group 1 was employed full-time, significantly less than the sample as a whole (67%), and in Atlanta 57% was employed full-time (vs. 73% for the sample). The higher income groups, particularly Group 4, were most likely to be employed full-time (77% in Seattle and 79% in Atlanta). In both cities, Group 3 tended to look more like Group 4 (in terms of employment status). Group 2 tended to have somewhat more homemakers, and in terms of the proportion that is employed full-time, it stands firmly in the middle of the lowest and highest income groups (see tables in Appendix A).

With respect to age, Groups 1 and 2 in both cities had a disproportionate number of younger people (under 34 years of age), and in Seattle, Group 1 also had a slightly higher proportion of 65-74 year olds (reflecting the retirees in this group). By contrast, Group 4 had a disproportionate number of respondents aged 45-64, and in both cities, the age composition of Group 3 generally mirrored the sample.

In Seattle, Income Group was significantly correlated with vehicle ownership. A higher proportion of Group 1 respondents had no vehicle (5% vs. 1% for all other groups), and they were also more likely to have only one vehicle. In Atlanta, all households had at least one vehicle, and income group was not as strongly related to vehicle ownership.

Geography

Geographic equity refers to the distribution of project impacts across different parts of a region or state. Given the layout and context of the two project sites, geographic equity was a larger concern in Seattle than Atlanta, as the route options in Atlanta parallel each other within a narrow band, while in Seattle, the crossing options for Lake Washington are geographically dispersed and only one of the two bridges was tolled. In Seattle, Wave 1 cross-lake route choice was used as a proxy for geographic equity. It was assumed that prior to tolling, users selected the optimal route for their trips. Changes in trip satisfaction were used to identify areas of concern for geographic equity. For example, were those who travelled on I-90 in Wave 1 more or less happy with their travel in Wave 2, regardless of how they now chose to cross the lake? Maps for HOV-2 use (pre-tolling) and Express Lanes use (post tolling) and Peach Pass ownership were generated to explore geographic equity in Atlanta.

Mode

In Seattle, Wave 1 cross-lake mode choice was also used as a proxy for modal equity, as transit was a potential cross-lake modal option. Again, trip satisfaction metrics were used to identify shifts in the relative happiness of transit users versus drivers. In Atlanta, those who commuted via a 2-person carpool in Wave 1 were of particular interest from a modal equity perspective, as they lost the free use of the Express lanes after tolling, so we explored changes in their use of the facility as well as changes in trip satisfaction among this group. Overall changes in mode, including transit ridership were also examined, though transit served a much smaller percentage of the population than in Seattle.

Seattle

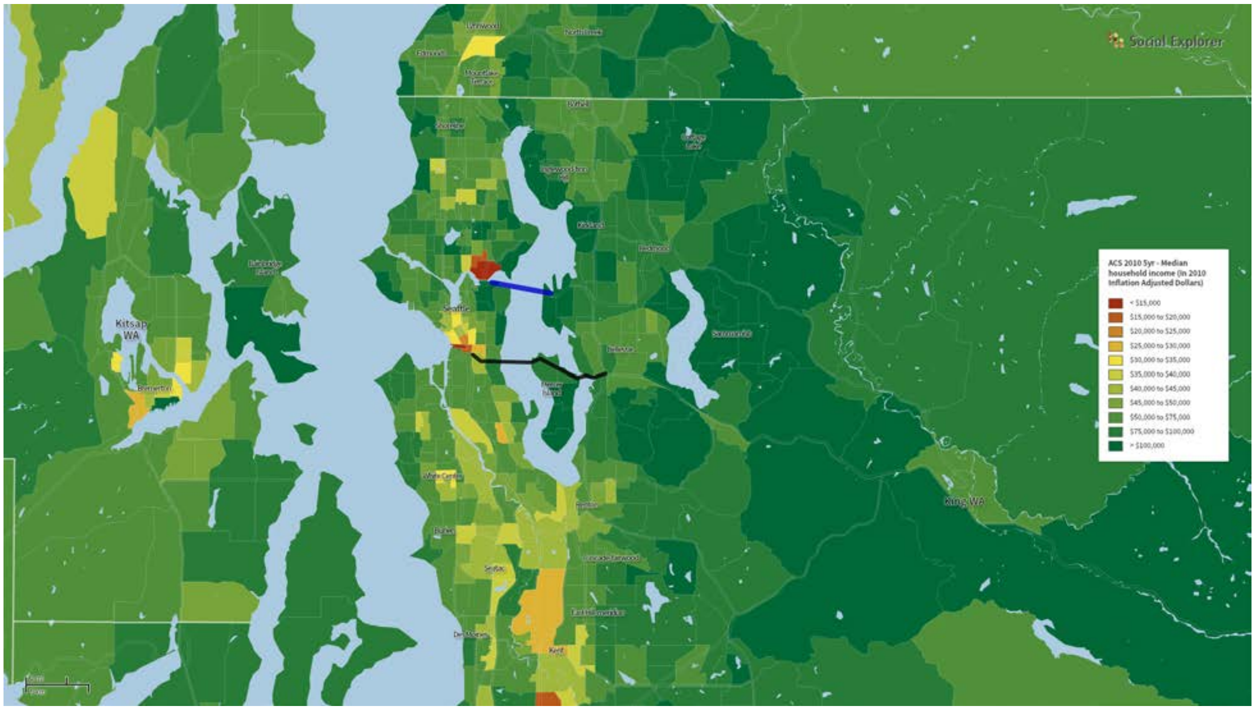
The following section describes the findings for Seattle, focusing first on income equity impacts, followed by modal and geographic equity impacts.

Income

Context

As noted in the literature review, it is important to place pricing projects in their regional context when exploring equity. In Seattle, even before the introduction of pricing on SR 520, wealthier households were more likely to cross the lake. The average household income of SR 520 users in our sample (before the implementation of tolling) was approximately $132,000, the highest income among all lake crossing groups. This finding makes sense, as the SR 520 bridge serves a wealthier than average population within the Seattle region. As can be seen in Figure 1, which shows median income by census tract in the Seattle metropolitan area, SR 520 (highlighted in blue) directly connects two of the wealthiest census tracts in the area and is the major crossing for the wealthier northern half of the metro area. The red low-income tract just north of the bridge is the University of Washington, and the behavior of students will be noted below. I– 90, the other major route across the lake is highlighted in black.

Figure 1: 2010 ACS 5-Year Estimates of Median Household Income for the Seattle Metropolitan Area



As other studies of traveler behavior in response to congestion pricing have found, use of SR 520 after tolling was lowest among lower income groups, though some low-income drivers still selected it as a cross-lake option. The average income of drivers on SR 520 rose from $132,000 to $140,000, while the average income on transit fell from $119,000 to $115,000. Overall, the average income of trip makers in the sample did not change ($126,374 in Wave 1 to $126,686 in Wave 2).

Changes in Trip-Making

In Wave 1, Seattle respondents recorded an average of 7.6 trips (to any destination) over their two-day diary periods, while households made an average of 13.2 trips. There were approximately 2 one-way trips across the lake per individual and 3.5 trips across the lake per household. Table 3 shows the change in individual trip counts by income group between the two waves.[5] When considering "All Trips" in Wave 1, the number of trips by individuals was not significantly correlated with income group. However, in Wave 2, the number of trips among the lowest income group (Group 1) fell disproportionately (by 20%), resulting in significantly fewer trips reported among this group, compared to the other income groups.

With regard to cross-lake trips, income is correlated with trip making behavior in both in Wave 1 and Wave 2. Even before the introduction of pricing on SR 520, wealthier households were more likely to

[5] Data for households shows the same percentage changes.

cross the lake. Following tolling, we see a differential decline in cross lake trips by income, with the lowest income groups decreasing their cross lake trips by 28% (more so than did other income groups). Thus the lowest income group had the largest decline in trips, both overall and cross-lake.

Following the implementation of tolling, drivers had four options to adjust their travel in order to avoid the toll: 1) Change route, 2) Change mode, 3) Change destination, 4) Forgo trips. They could also adjust the timing of their trips to avoid the peak toll. Some drivers had fewer options than others; for example, some destinations are easier to replace with a same-side alternative than others. When exploring the equity impacts, both the tolls paid and whether a trip was foregone were explored to the extent possible. Given the significant reduction in overall trips across the board and particularly among lower-income users, the data suggest tolling may have created a burden due to lost mobility. This burden could be lessened if users were able to shift trips to another mode or access the same services without crossing the lake. As detailed below in the next two sections, there were some shifts to other routes and to transit, but this did not compensate for the foregone trips.

Table 3: Overall Change in Individual Trips

Income Group	All Trips Individual, Wave 1	All Trips Individual, Wave 2	Percent Change	Crosslake Individual, Wave 1	Crosslake Individual, Wave 2	Percent Change
Income Group 1 (~$37K)	7.23	5.79	-20%	1.70	1.22	-28%
Income Group 2 (~$70K)	7.44	6.44	-13%	1.82	1.49	-18%
Income Group 3 (~$120K)	7.73	6.48	-16%	2.05	1.69	-18%
Income Group 4 (~$200K)	7.57	6.41	-15%	2.27	1.83	-19%
Total	**7.60**	**6.43**	**-15%**	**2.02**	**1.63**	**-19%**

Note: Group 1= 0-3 times the poverty level; Group 2=3-5 times the poverty level; Group 3=5-10 times the poverty level; Group 4=10+ times the poverty level

Route Changes

It is clear that many drivers chose to change routes in order to avoid the toll, as we see the largest decrease in trips on SR 520. Adjusted income was not a significant determinant of cross-lake route choices for typical travel in Wave 1, but it was a significant predictor in Wave 2. Lower-income drivers were more likely to switch off of SR 520 on to another route or forgo a trip altogether, though use of 520 did fall across all income groups, as can be seen in Table 4 below. Also interesting is the variation in shifts to transit, with middle-income users seeing larger percentage change increases than lower or higher income users. All income groups increased their use of SR 522 and other routes/modes in the corridor, though higher income groups had relatively larger shifts to SR 522, whereas the lowest income group had the largest shift to other routes/modes in the corridor.

Table 4: Change in Crosslake Trips

Income Group	Change in Trips on SR 520	Change in Trips on I-90	Change in Trips on SR 522	Change in Trips on Transit	Change in Trips by Other Modes/Routes	Change in Non-Crosslake Trips
Income Group 1 (~$37K)	-64%	-17%	+33%	-11%	+50%	-28%
Income Group 2 (~$70K)	-61%	+10%	+57%	+17%	+12%	-18%
Income Group 3 (~$120K)	-49%	+4%	+104%	+3%	+14%	-18%
Income Group 4 (~$200K)	-37%	-3%	+86%	-13%	+76%	-19%
Total	**-47%**	**0%**[6]	**+84%**	**+1%**	**+22%**	**-19%**

Note: Group 1= 0-3 times the poverty level; Group 2=3-5 times the poverty level; Group 3=5-10 times the poverty level; Group 4=10+ times the poverty level

Mode Shifts

Looking at the Wave 1 use of modes, we find there are no significant differences by income group. All groups made the large majority of their trips by auto. Group 1 (those with reported incomes 0 to 3 times the poverty level for their household composition) were most likely to use transit, but not by a significant margin. In Wave 2, there are no significant changes by income group in their use of modes, though there is a trend towards greater transit use among the lower income groups.

[6] While the absolute number of trips was essentially unchanged on I-90, since the overall volume of travel in the corridor was down significantly, holding steady on the number of trips actually meant that I-90's "share" of trips in the corridor increased.

Table 5: Mode Shifts by Income Group

	Driving	Vanpool	Transit	Walking/Biking	Other
Income Group 1 (~$37K)					
Wave 1	83%	0%	9%	8%	1%
Wave 2	80%	0%	11%	9%	0%
Income Group 2 (~$70K),					
Wave 1	83%	0%	7%	9%	0%
Wave 2	81%	0%	10%	8%	0%
Income Group 3 (~$120K)					
Wave 1	83%	1%	8%	8%	1%
Wave 2	83%	1%	9%	7%	1%
Income Group 4 (~$200K)					
Wave 1	81%	1%	7%	11%	1%
Wave 2	82%	1%	8%	8%	1%

Note: Group 1= 0-3 times the poverty level; Group 2=3-5 times the poverty level; Group 3=5-10 times the poverty level; Group 4=10+ times the poverty level

The mode shift is much more pronounced when looking at cross-lake trips. In exploring the extent to which corridor users of various incomes were willing and able to switch modes, a couple of key trends are apparent (see Table 6 below). First, the highest income group was the least likely to switch to transit and they have the highest incidence of vanpool use. Second, the two middle income groups shifted most to transit, more so than did the lowest income group. The smaller than expected shift to transit among Group 1 was driven largely by those who were employed full-time. Among not employed individuals (retirees, homemakers, full-time students, and unemployed individuals), transit use increases as income decreases. Possible reasons for the smaller shift among employed, lower income respondents could include less flexible schedules. Group 1 had the highest percentage of respondents selecting "no schedule flexibility" (44%) when asked how flexible their schedule was (this compares to 19% for Group 4).

Table 6: Change in Crosslake Mode Share by Income, Wave 1 to Wave 2

	Driving	Vanpool	Transit	Walking/Biking	Other
Income Group 1 (~$37K)					
Wave 1	81%	1%	18%	1%	0%
Wave 2	78%	0%	22%	0%	0%
Income Group 2 (~$70K),					
Wave 1	77%	1%	20%	1%	1%
Wave 2	69%	1%	27%	2%	0%
Income Group 3 (~$120K),					
Wave 1	80%	2%	14%	1%	0%
Wave 2	75%	2%	21%	1%	1%
Income Group 4 (~$200K)					
Wave 1	83%	2%	14%	1%	0%
Wave 2	80%	3%	15%	1%	2%

Note: Group 1= 0-3 times the poverty level; Group 2=3-5 times the poverty level; Group 3=5-10 times the poverty level; Group 4=10+ times the poverty level

Trip Purpose and Destination Shifts

With regards to trip purpose and the ability to change destinations, in Wave 1, lower income households made fewer work related trips and more trips to pick up and drop off others than higher income households. This is consistent with group demographics, in which 66% of low-income individuals were employed compared with 82% of total respondents.

Table 7 shows the percentage change in cross-lake trips by trip purpose and income group. Compared to the other income groups, Group 1 (the lowest income group) had a dramatic drop in cross-lake discretionary trips (-51%), and to a lesser extent, in trips to work/school/child care (-34%). The decrease in cross-lake discretionary trips is not compensated by a proportional increase in the share of non-cross-lake discretionary trips, at least for employed individuals, though the absolute number of non-corridor trips increased for that group. Part-time and not employed individuals made relatively more work/school/child care trips off the corridor, particularly among the lower two income groups, though sample sizes for the part-time and not employed individuals are smaller (n = 50-120 trips per income group).

Table 7: Percent Change in Number of Cross-Lake Trips by Purpose and Income[7]

	Home	Work/School/ Child Care	Discretionary	Other	Total
Income Group 1(~37K)	-9%	-34%	-51%	-27%	-28%
Income Group 2 (~70K),	-16%	-18%	-27%	-17%	-18%
Income Group 3 (~120K)	-13%	-19%	-19%	-30%	-18%
Income Group 4 (~200K)	-19%	-18%	-24%	-16%	-19%
Total	-15%	-20%	-25%	-24%	-19%

Note: Group 1= 0-3 times the poverty level; Group 2=3-5 times the poverty level; Group 3=5-10 times the poverty level; Group 4=10+ times the poverty level

Opinions on Tolling

Two attitudinal questions related to tolling were administered in both waves of the survey, including: "Tolls are unfair to people with limited incomes" and "I will use a toll route if the tolls are reasonable and I will save time." In both waves of the survey, lower income individuals (compared to those with higher income) were more likely to agree that tolls are unfair to those with limited incomes and less likely to agree that they will use a toll route to save time.

Attitudes toward equity were correlated with income in both waves of the survey, as lower income individuals were significantly more likely than higher income individuals to agree that tolls are unfair to those with limited income. With respect to changes in opinion, however, it is interesting to note that agreement ratings dropped somewhat for the two lowest income groups and remained relatively stable for the two higher income groups. In Wave 1, 69% of Group 2 agreed (combined ratings of "strongly agree," "agree," or "agree somewhat") that tolls are unfair, and in Wave 2 63% did so. Among Group 1, the percent agreeing dropped from 71% to 67% (with an 11% drop in the proportion "strongly agreeing").

Attitudes toward using a toll route were also correlated with income in both waves, with higher income groups being significantly more likely to agree that they would use a toll route. Across the survey waves all groups became more positive in their attitudes toward using a toll route. Among the lowest income

[7] Respondents were given thirteen options for trip purpose to ensure that they were able to quickly classify the trip. To get sufficient data for analysis, those thirteen purposes were grouped into Home (self-explanatory), Work/School/Child-Care (as trips made regularly and unlikely to change), Discretionary (including social/recreational, personal business, meals out, etc.), and Other (picking or dropping someone off, or the catchall other category provided as one of the thirteen).

group, the percent agreeing they would use a toll route increased from 48% in Wave 1 to 57% in Wave 2. Among the other income groups the shift in positive attitudes was even greater.

Figure 2: Opinion: Tolls Are Unfair to Those with Limited Incomes

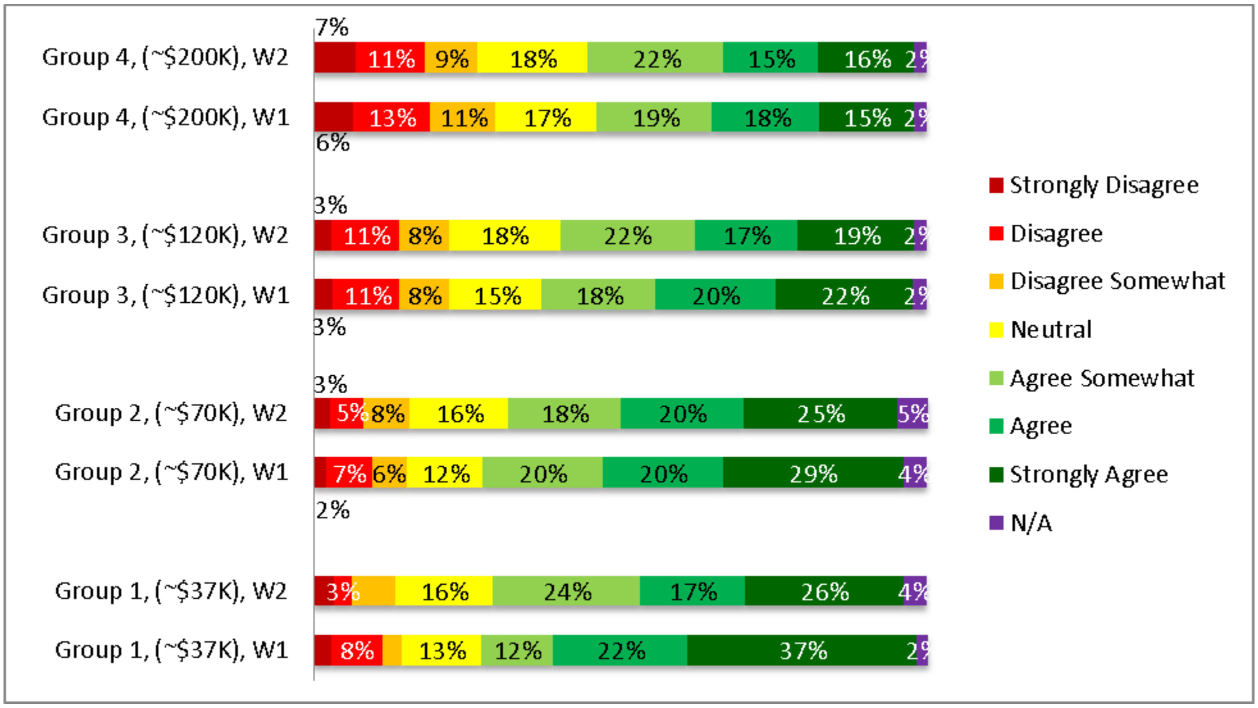
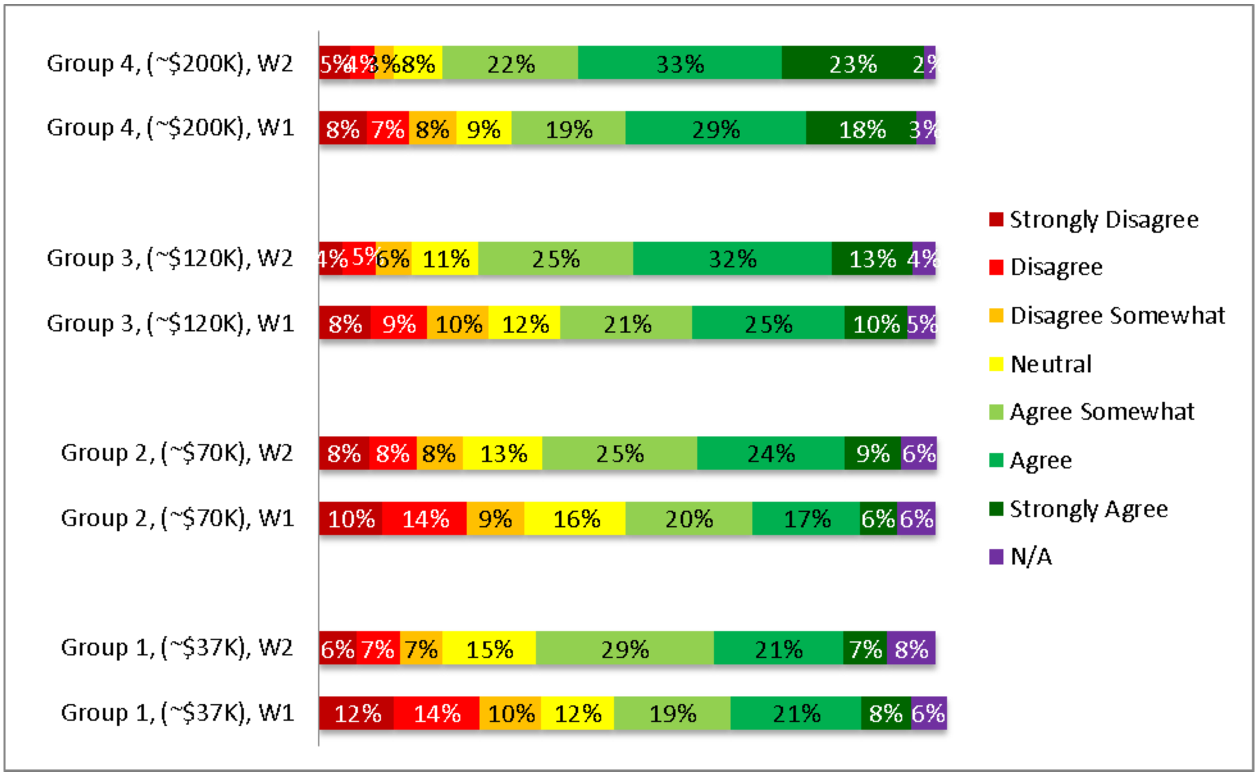


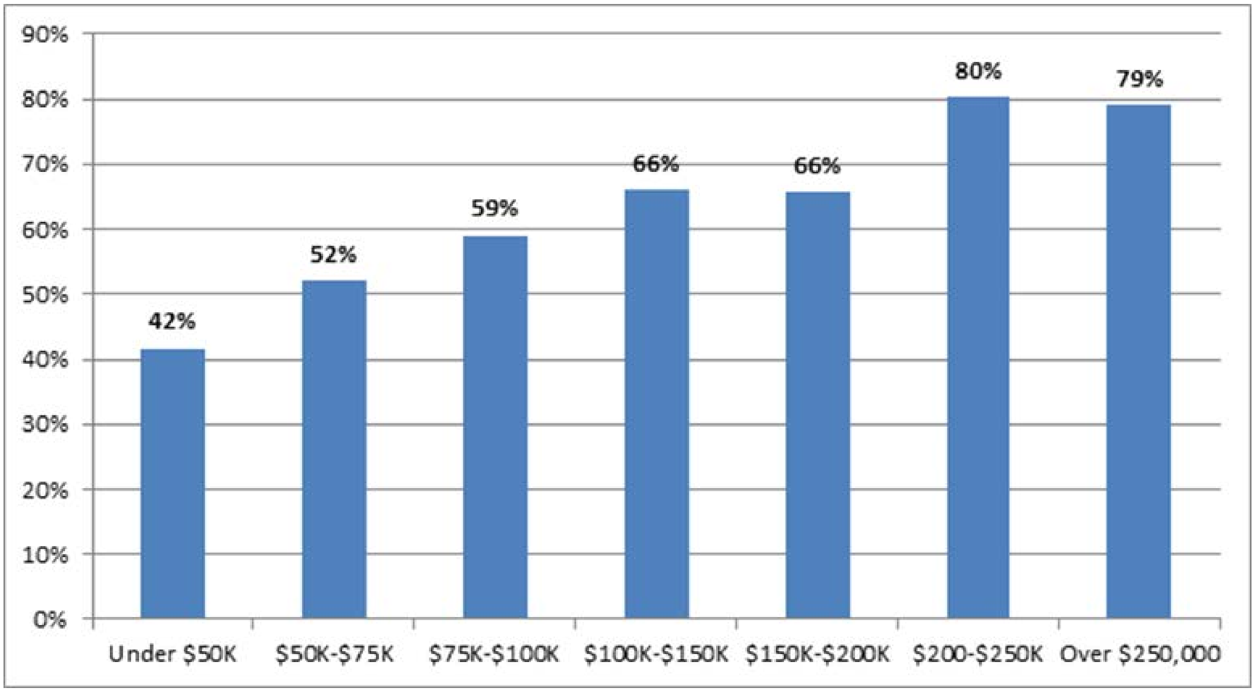
Figure 3: Opinion: I Will Use a Toll Route if The Tolls are Reasonable and I will Save Time



Transponder Ownership and Tolls Paid

Transponder ownership and use of pay-by-plate were both directly correlated with higher incomes. While lower-income households were less likely to purchase a transponder, the most frequent reason given was infrequent use of tolled roads. Pay-by-plate was used more by higher income low frequency users, and did not appear to be used as a substitute for transponders among lower income groups.

Figure 4: Ownership Rates for Good to Go! Transponders, by Household Income Group



Higher income households paid more in tolls, with the highest income households (>$200K) recording an average of about $3 in tolls paid over the two day diary period, while households under $50K paid an average of about $1. The average toll paid per trip was roughly equal for all income levels at approximately $3, suggesting that the difference in the amount paid overall was in the number of trips made. Lower-income households cut back on travel much more, reducing their toll burden by choosing to either switch off 520 to another route, mode, or destination, or to forgo the trip.

Figure 5: Total Tolls Paid by Household Members over 2-Day Travel Diary Period: Average by Household Income Group

Mode

Overall, the panel survey indicated that there was a modest increase in the use of transit in the SR 520 corridor (from 15% in Wave 1 to 18% in Wave 2)[8] and a slight drop in driving trips (from 79% to 74%). Trip satisfaction metrics were also used to assess modal equity impacts. In both waves of the survey, respondents making a transit trip across the lake were asked to rate their satisfaction with their transit travel time, wait time at stop, reliability of the service and availability of seats. Similarly, drivers crossing the lake were asked to rate their satisfaction with their overall driving time, their travel speed and the predictability of their driving time.

Overall in Wave 1, 70% or more of transit trips were rated as satisfactory (either very satisfied, satisfied or somewhat satisfied), with a plurality of transit users being "satisfied" on all measures. Transit trip satisfaction remained fairly stable across the survey waves, with the exception of availability of seating, where satisfaction decreased somewhat, from 77% to 70% satisfied. On the other hand, among drivers, there was an increase in satisfaction on all three measures – driving time, driving speed, and predictability. These data suggest that with the shifts to transit, there may have been some issues in accommodating new users with seating; however the drop in satisfaction on this measure was relatively minimal and satisfaction on all other measures remained high, so modal equity does not appear to be a concern.

[8] Many of the transit improvements occurred prior to our Wave 1 survey.

Figure 6: Trip Satisfaction among Transit Users

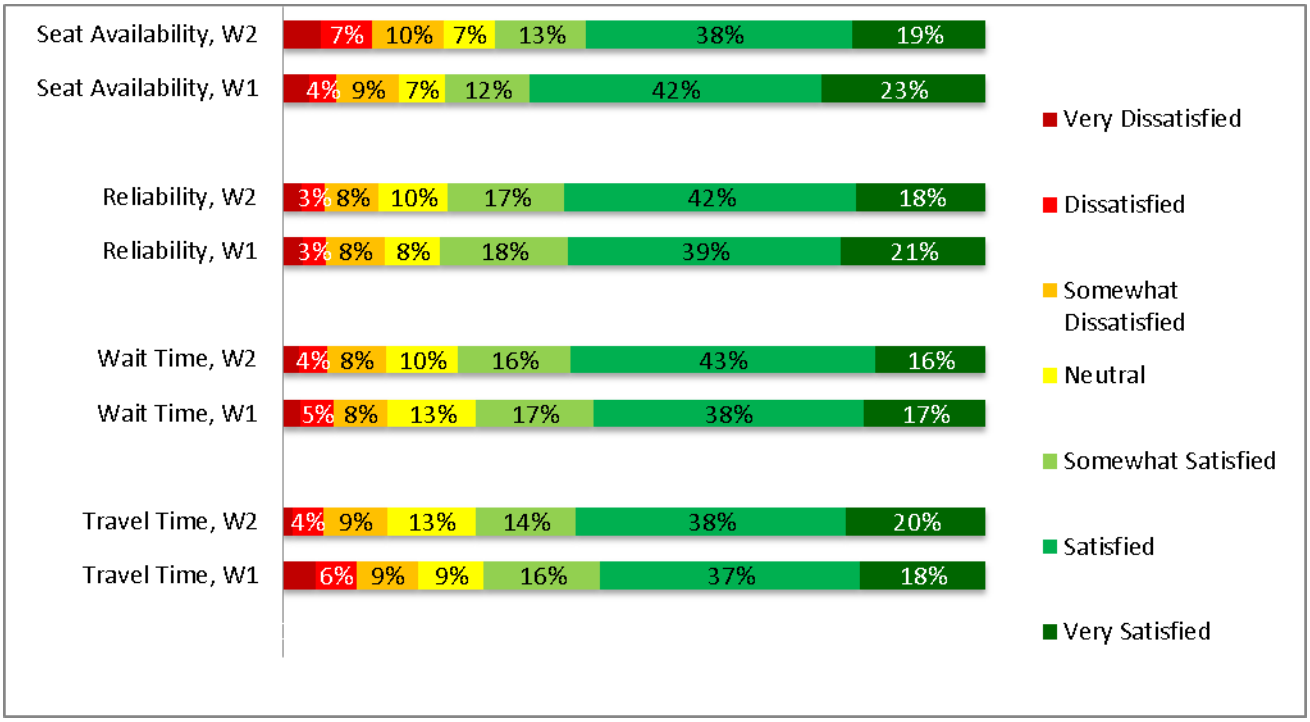
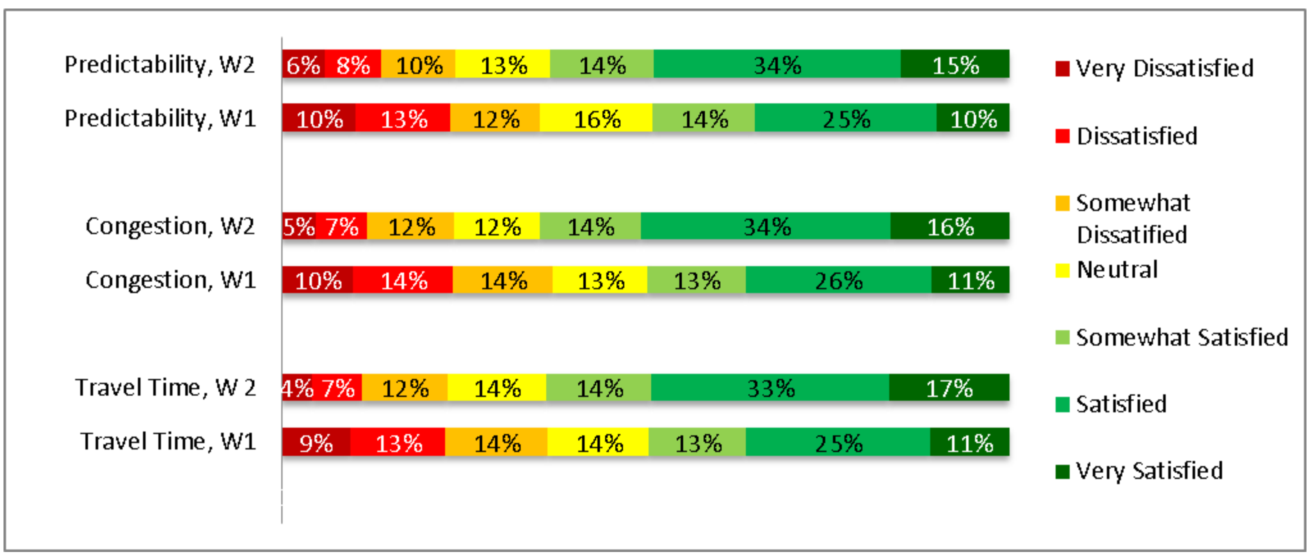


Figure 7: Trip Satisfaction among Drivers



Geography

Following the implementation of tolling, there was a significant drop in the share of corridor trips on SR 520 (from 31% in Wave 1 to 21% in Wave 2), whereas the share of trips on I-90 increased (from 46% to 49%), as did the share of trips on SR 522 (2% to 4%). Such shifts suggest the potential for geographic equity impacts, which we explored by analyzing trip satisfaction measures by route: SR 520 vs. I-90 vs. SR 522.

In Wave 1, differences in satisfaction among the three roads were minor, though statistically significant. SR 520 drivers were the least satisfied of all drivers overall, while drivers on I-90 were the most satisfied. While these differences were statistically significant, the magnitude of the differences was quite small, as the mean response on each route for each characteristic was still “neutral”. Cross-lake trips utilizing SR 520 were on average a mile shorter than trips using I-90.

In Wave 2, trip satisfaction on SR 520 increased significantly, whereas satisfaction for I-90 trips decreased. In fact, drivers on SR 520 were, on average, almost a full point (on a 7-point scale) happier on all three elements than drivers on I-90. Drivers who chose I-90 in Wave 1 were also less satisfied than drivers who chose SR 520 in Wave 1 whether they drove on SR 520 or I-90 in Wave 2.

Table 8: Summary of Mean Satisfaction Scores for Peak-Period Trips Around or Across Lake Washington, Before and After SR 520 Tolling

Scale: 1=Highly Dissatisfied, 4=Neutral, 7=Highly Satisfied
“Peak Period” = Trips departing 7-9 AM or 3-6 PM
** denotes statistically significant change*

	Pre-Tolling	Post-Tolling	Change
Driving Trips on SR 520:	**(N=1,840)**	**(N= 1,032)**	
Satisfaction with Travel Time	3.41	5.17	+1.76 *
Satisfaction with Travel Speed	3.35	5.16	+1.81 *
Satisfaction with Predictability	3.47	5.13	+1.66 *
Driving Trips on I-90:	**(N=1,306)**	**(N=1,199)**	
Satisfaction with Travel Time	3.98	3.87	-0.11 *
Satisfaction with Travel Speed	3.93	3.81	-0.12 *
Satisfaction with Predictability	4.03	3.68	-0.35 *
Driving Trips on SR 522:	**(N= 104)**	**(N= 169)**	
Satisfaction with Travel Time	3.34	3.66	+0.32 *
Satisfaction with Travel Speed	3.39	3.64	+0.25 *
Satisfaction with Predictability	3.91	3.97	+0.06

In addition to the decrease in trip satisfaction among I-90 users, the attitudinal questions also provide insight on the impact of tolling on their travel experiences. I-90 users were significantly *more* likely than SR 520 users to agree that “Overall, I am spending more time stuck in traffic since tolling started on SR 520,” (4.6 vs. 2.6), and they were *less* likely to agree that “tolling on SR 520 has improved my travel in the region" (2.6 vs. 4.9 respectively).[9] Taken as a whole these findings suggest that by tolling only one of the two major Lake Washington crossings, geographic inequity was introduced due to increased congestion on I-90.

Feasibility and Equity of Other Financing Options

Aside from the congestion reduction benefits, SR 520's tolls are being used to pay for the bridge's replacement. In the absence of toll funding, these improvements would be financed via taxation. Because Washington does not have a state income tax, the funding source would likely be an increase in the sales tax, which is regressive with respect to income.

Existing research by Taylor and Schweitzer on SR 91 in California has found that because tolls are paid by users, they place less of a burden on those with very low-incomes (under $25,000 per year in the Taylor and Schweitzer study) than a sales tax. Revenue from a sales tax places a disproportionate (relative to use of the road) burden on the very rich and very poor, while SR 91 tolls are paid largely by middle class users.

While this study does not have access to state taxation data to produce a similar quantitative analysis for the SR 520 project, it would seem that a similar conclusion should hold in this case. SR 520 users were already wealthier than average and the income of the average bridge user rose further under tolling, suggesting that middle and higher income households share most of the burden. However, there are two areas that should be explored in future research: the magnitude of the impact of lost mobility for lower income users and the sensitivity of the quantitative analysis performed by Taylor and Schweitzer to the selection of an income level to define low-income. Taylor and Schweitzer selected $25,000, which is just over the federal poverty level. This analysis adjusted for household size and used a broader definition of "low income" that included household with incomes up to three times the poverty level, potentially including households making up to $99,999.[10] The difference in the populations considered may impact the degree of regressivity found.

Atlanta

As previously described, the Atlanta CRD project involved the conversion of an existing high occupancy vehicle (HOV-2) lane to a dynamically priced high occupancy toll (HOT-3) lane (also called "Express lanes"), combined with an increase in the occupancy requirement from 2+ to 3+. Another key requirement of the system is that all users must have a Peach pass transponder to access the Express Lanes. In advance of making a trip, users must register their trip in either toll mode status (if one or two

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[9] Mean agreement scores are presented for a seven point scale, where 1=strongly disagree, 4=neutral, and 7=strongly agree.

[10] Survey respondents selected from a set of income ranges, the mid-point of which was then assigned to the household as an income for adjustment to the poverty level based on household size. As a result, there is the possibility that some members of the lowest-income group have much higher incomes than would have been included had finer-grained income information been available.

occupants in the vehicle) or in non-toll mode status (for vehicles with three or more occupants, alternative fuel vehicles, or motorcycles).

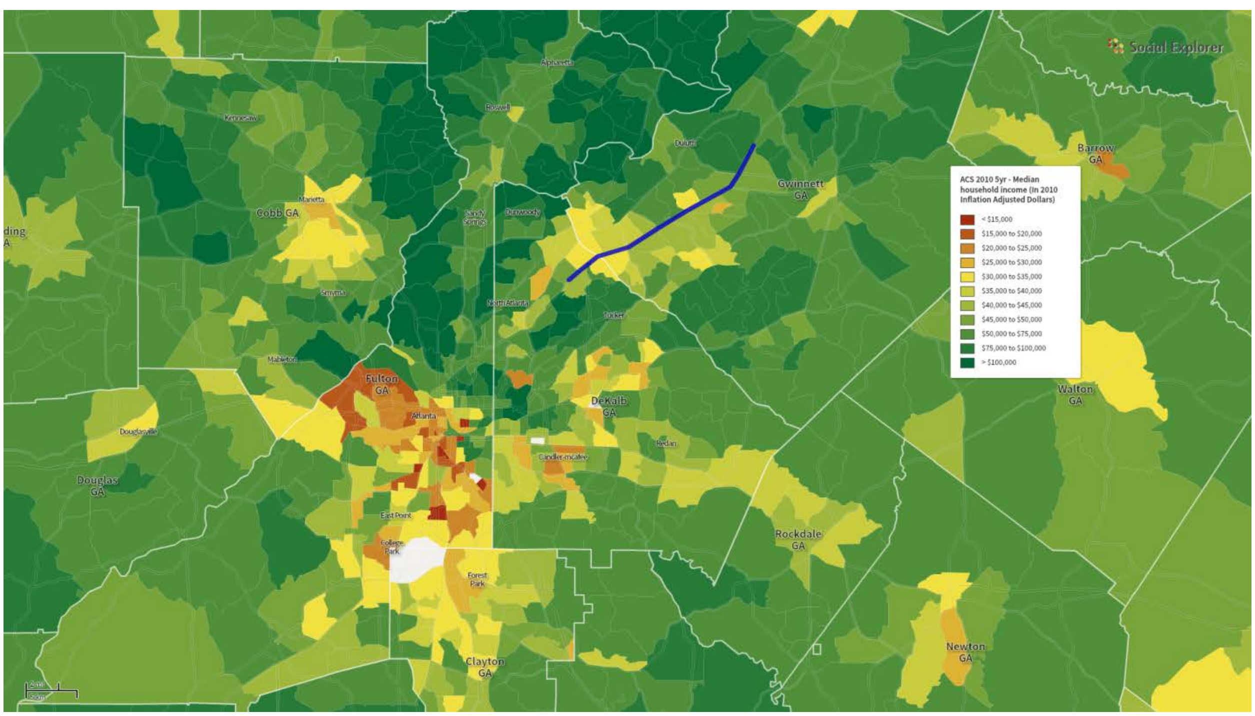
The following sections address the income, modal and geographic equity impacts of the I-85 tolling project.

Income

Context

Wave 1 HOV lane users in Atlanta (both as carpools and alternative fuel vehicle owners) had an average household income of almost $110,000, the highest among I-85 corridor users. Figure 8, below, places the I-85 corridor, highlighted in blue, in the context of income distribution of metro Atlanta. Unlike SR 520, it does not directly link wealthy areas, but does serve a wealthier than average population. Median incomes in census tracts along the corridor range from $30,000 to $90,000. The median income for the Atlanta metropolitan area in 2010 was $53,182, while Gwinnett County, in which a majority of the corridor lies, had a median income of $63,219. The average income of the Express Lane user in Wave 2 was roughly the same as that of the HOV user in Wave 1 ($110,956 vs. $109,830, respectively) and is only marginally higher than that of the general purpose user ($97,405 in Wave 1 and $98,126 in Wave2). The only significant change in average income was on transit, where the income increased from $95,000 to $103,000.

Figure 8: 2010 ACS 5-Year Estimates of Median Household Income for the Atlanta Metropolitan Area



Changes in Trip-Making

In Wave 1, individuals made an average of 6.4 trips over the two days, while households made an average of 11.3 trips. There were approximately 2 trips on I-85 per individual and 3.5 trips on I-85 per household. Table 9 shows the change in individual trip counts by income group between the two waves. The number of trips by individuals and households was not significantly correlated with income. Regarding overall trips, the two middle income groups tended to make the most trips, in both Wave 1 and Wave 2, and there is little difference between the lowest and highest income groups in their trip-making behavior. Regarding I-85 trips, the lowest income group recorded slightly fewer trips than other income groups, but the differences are not large.

All income groups reduced their trips, with greater reductions occurring for overall trips than for I-85 trips. In general, the reduction in trips was fairly similar for all the income groups.

Table 9: Overall Changes in Individual Trips

Income Group	Individual, Wave 1	Individual, Wave 2	Percent Change	I-85 Individual, Wave 1	I-85 Individual, Wave 2	Percent Change
Income Group 1 (~$44K)	6.21	5.02	-19%	1.82	1.61	-12%
Income Group 2 (~$75K)	6.52	5.57	-15%	2.03	1.80	-11%
Income Group 3 (~$113K)	6.56	5.53	-16%	2.11	1.79	-15%
Income Group 4 (~$182K)	6.15	4.87	-21%	2.06	1.74	-16%
Total	**6.43**	**5.38**	**-16%**	**2.01**	**1.75**	**-13%**

Note: Group 1=0-3 times poverty level; Group 2=3-5 times poverty level; Group 3=5-10 times poverty level; Group 4=10+ times the poverty level

Route and Mode Changes

In Wave 1, adjusted income was related to corridor route and mode choices for the panel sample. As can be seen in Table 10, lower income groups were somewhat less likely to use HOV lanes (particularly in comparison to the wealthiest group) or to take transit on the corridor. In Wave 2 (see Table 11), use of the Express Lanes (vs. the HOV Lanes) rose across the board, with use being only somewhat greater among those with higher incomes compared to those with lower incomes. The share of trips on I-85 increased for all income groups, with the exception of the highest income group, who had a greater share of trips on "other roads in the corridor."

Table10: Wave 1 Use of Routes/Modes in the Corridor by Income Group

Income Group	HOV	Alt	GP	Transit	Other Roads
Income Group 1 (~$44K)	4%	0%	58%	5%	33%
Income Group 2 (~$75K)	6%	0%	56%	7%	31%
Income Group 3 (~$113K)	5%	0%	57%	7%	31%
Income Group 4 (~$182K)	7%	1%	52%	10%	31%
Total	**5%**	**0%**	**57%**	**7%**	**31%**

Note: Group 1=0-3 times poverty level; Group 2=3-5 times poverty level; Group 3=5-10 times poverty level; Group 4=10+ times the poverty level

Table 11: Wave 2 Use of Routes/Modes in the Corridor by Income Group

Income Group	Express	Alt	GP	Transit	Other Roads
Income Group 1 (~$44K)	8%	0%	64%	6%	23%
Income Group 2 (~$75K)	8%	0%	59%	7%	27%
Income Group 3 (~$113K)	10%	1%	55%	8%	26%
Income Group 4 (~$182K)	10%	1%	48%	9%	32%
Total	**9%**	**0%**	**57%**	**7%**	**26%**

Note: Group 1=0-3 times poverty level; Group 2=3-5 times poverty level; Group 3=5-10 times poverty level; Group 4=10+ times the poverty level

Trip Purpose and Destination Shifts

In Wave 1, the breakdown of trip purpose for corridor trips was relatively similar among income groups, as shown in Table 12.

Table 12: Wave 1 Corridor Trip Purpose Shares

	Home	Work/School	Discretionary	Other
Income Group 1 (~44K)	33%	46%	16%	5%
Income Group 2 (~75K)	36%	47%	11%	6%
Income Group 3	34%	49%	13%	4%

	Home	Work/School	Discretionary	Other
(~113K)				
Income Group 4 (~182K)	33%	46%	16%	6%
Total	**34%**	**47%**	**13%**	**5%**

Note: Group 1=0-3 times poverty level; Group 2=3-5 times poverty level; Group 3=5-10 times poverty level; Group 4=10+ times the poverty level

Wave 2 saw a significant decline in the number of trips, but it occurred pretty much across the board, suggesting factors other than income were in play. In general, the share of discretionary trips declined relative to home and work, both overall and along the corridor.

Table 13: Percentage Change in Corridor Trips by Purpose and Income

	Home	Work/School	Discretionary	Other	Total
Income Group 1 (~44K)	5%	-10%	-39%	-46%	-11%
Income Group 2 (~75K)	-6%	-12%	-15%	-33%	-12%
Income Group 3 (~113K)	-12%	-16%	-19%	-25%	-15%
Income Group 4 (~182K)	-3%	-12%	-45%	-37%	-16%
Total	**-7%**	**-14%**	**-25%**	**-32%**	**-14%**

Note: Group 1=0-3 times poverty level; Group 2=3-5 times poverty level; Group 3=5-10 times poverty level; Group 4=10+ times the poverty level

Opinions on Tolling

With respect to the equity attitudinal measure, the proportion agreeing that “tolls are unfair to those with limited income” was fairly similar across all the income groups in Wave 1, with 67% to 75% agreeing with the statement. In Wave 2, agreement dropped across the board, though the lowest income group had the smallest shift in opinion. In Wave 1, 67% of the lowest income group agreed that tolls are unfair, and in Wave 2 61% did so (the percent strongly agreeing actually increased, from 28% to 35%). Among the wealthiest group, however, agreement dropped from 71% to 44%, a decline of 27 percentage points.

A majority of all income groups agreed that they would use a toll route to save time in Wave 1, with little difference in opinion by income group. However, all groups became significantly more negative towards tolling in Wave 2. Among Group 1, the percent agreeing they would use a toll route decreased from 61% in Wave 1 to 38% in Wave 2. Groups 2 and 3 saw a similar shift in opinion. While the wealthiest group was also less likely to say they would use a toll route in Wave 2 (52% vs. 64% in Wave 1), the shift was significantly smaller than found for all other income groups.

Figure 9: Opinion: Tolls Are Unfair to Those with Limited Incomes

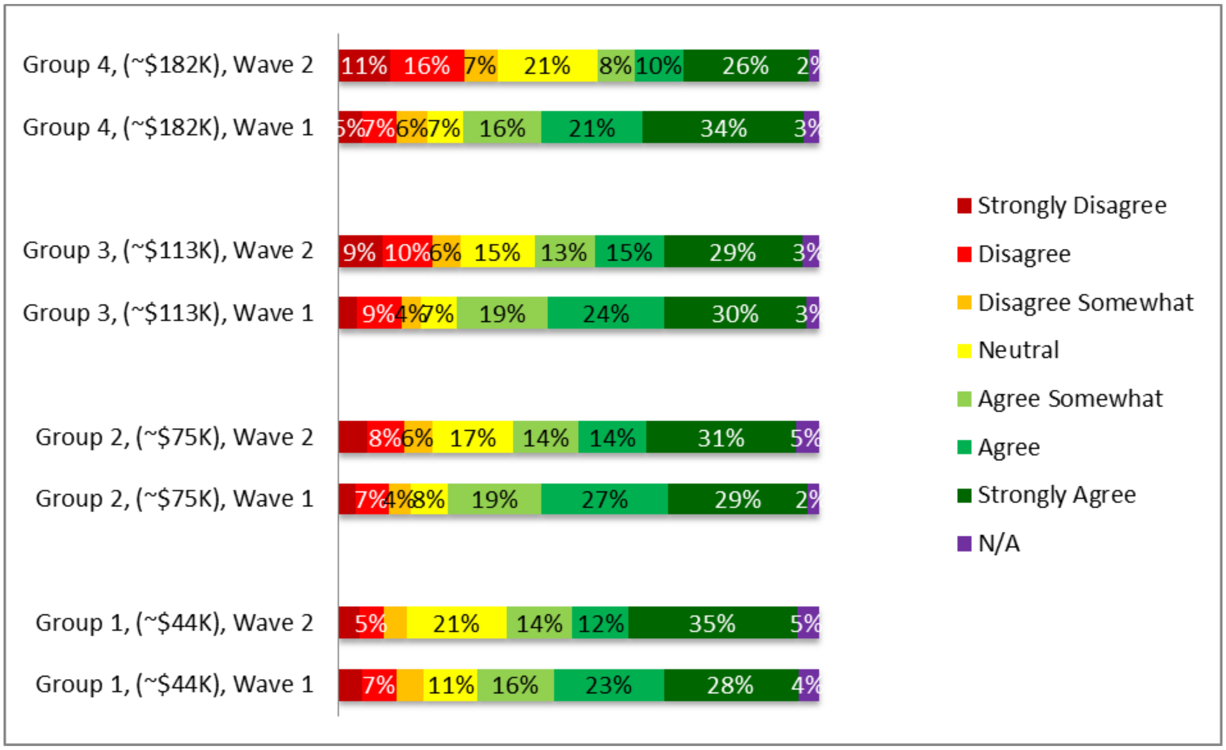
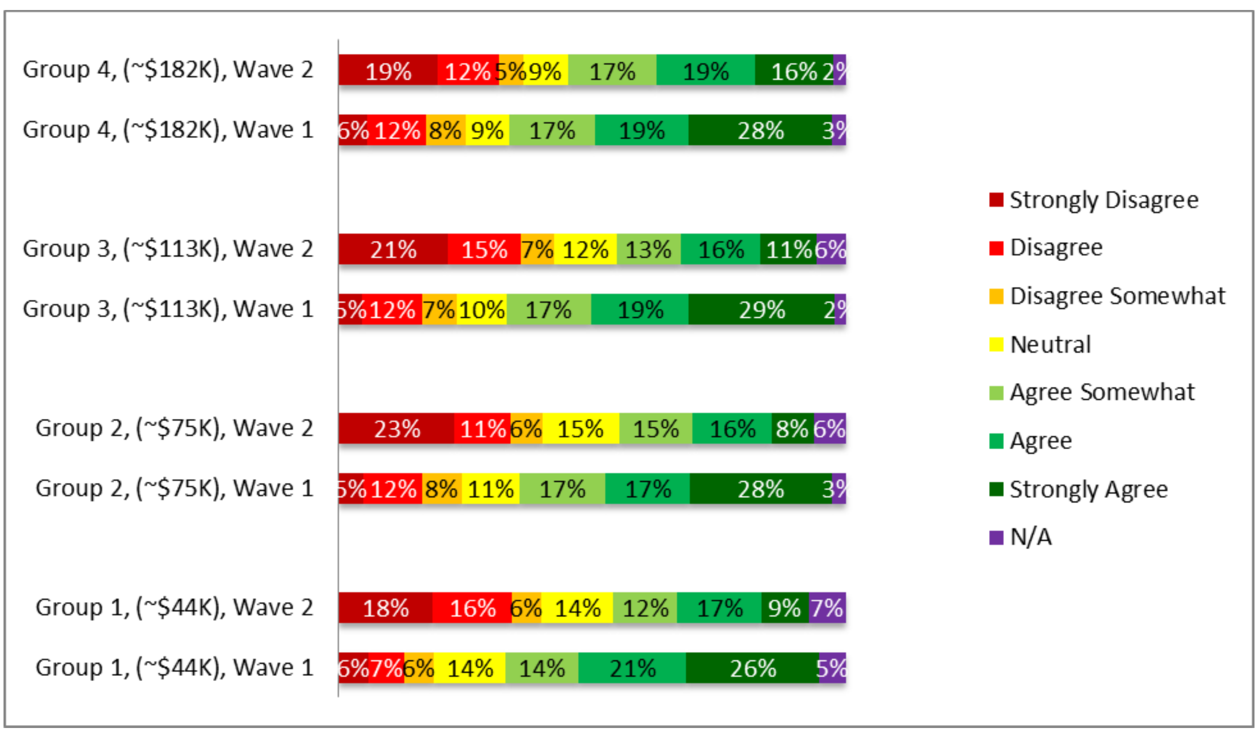


Figure 10: Opinion: I Will Use a Toll Route if The Tolls are Reasonable and I will Save Time



Transponder Ownership and Tolls Paid

In the Atlanta panel survey, one-third of households reported owning a Peach Pass. Among these households, income did significantly predict pass ownership and the number of passes owned, with higher income households being more likely to own a Peach Pass, Among those who did not obtain a Peach Pass, the three reasons cited most often included: “Tolls are too expensive” (42%), “Don’t use toll roads enough” (40%) and “Against tolling, in general” (39%). There was little variation by income for reasons given. Unlike in Seattle, income was not a significant predictor of the amount of tolls paid; however, the lowest income group did pay a higher average toll compared to the highest income group ($2.66 vs. $2.04). These data should be interpreted with caution, however, due to the relatively small sample sizes for the lowest and highest income groups.

Table 14: Average Toll Paid by Income Group

	Average Toll Paid	Sample size
Income Group 1 (~$44K)	$2.66	66
Income Group 2 (~$75K)	$2.29	115
Income Group 3 (~$113)	$2.53	243
Income Group 4 (~$182)	$2.04	48
Total	$2.47	472

Mode

The key modal equity concern in Atlanta was 2-person carpools. The State Road and Tollway Authority raised the occupancy requirement from 2+ to 3+ when it implemented the HOT lane. As a result, 2-person carpools currently using the HOV lane either had to pay to use the lane, find another person to carpool with, or switch to the general purpose lanes. In addition to carpools, we looked at transit use, which rose from 2.4% to 2.7% between Wave 1 and Wave 2, a change that was not statistically significant. Unfortunately, there were too few transit trips to support an in-depth analysis of changes in transit behavior.

Overall, the travel diary data reveal a clear shifting of carpools off of the Express Lanes. Across the two survey waves, vehicle occupancy dropped significantly in the HOV lane/Express Lane, from 2.22 in Wave 1 to 1.18 in Wave 2. At the same time, vehicle occupancy rose on the I-85 general purpose lanes, from a mean of 1.07 to 1.18, as carpools shifted out of the HOV-2 lanes once they could no longer use the lanes for free.

Within the total sample, very few respondents – only 1% -- made trips in in both the HOV lanes (Wave 1) and the Express Lanes (Wave 2). A significantly larger proportion of respondents - 10% - were new users to the Express Lanes, having never made an HOV lane trip in Wave 1. Five percent of respondents were HOV lane users who did not report any Express Lane trips in Wave 2. This data suggests that the HOV-2 users and Express Lane users were two fairly distinct populations, with little overlap. The significant majority of trips in the Express Lanes were solo drivers who paid a toll (82%), with an additional 5% being motorcycles or AFV, so for the most part, solo drivers replaced carpools in the Express Lanes.

To assess in more detail how tolling affected 2-person carpools in the HOV lanes, we flagged those respondents who made any HOV-2 trips in Wave 1 and compared the profile of their I-85 corridor trips in Wave 1 vs. Wave 2. Overall, we find that they made somewhat fewer trips on I-85 in Wave 2 (69% in Wave 2 vs. 79% in Wave 1). There was some movement to "other roads in the corridor" (27% of their corridor trips used other roads in Wave 2 compared to 20% in Wave 1), and minimal movement to transit (approximately 4-5 respondents).

Table 15: Profile of Corridor Trips Among Respondents Making HOV-2 Trips in Wave 1 (based on trip diaries)

	Wave 1	Wave 2
Drove on I-85	79%	69%
Drove and Transit	.4%	.9%
Transit Only	1.4%	2.9%
Other Roads in the Corridor	20%	27%
Number of Trips	534	401

Among these Wave 1 HOV-2 users, we see some significant shifting in their use of the general purpose lanes and the HOV/Express Lanes. In Wave 1 64% of their I-85 trips were in the HOV lanes; in Wave 2 only 19% of their trips were made in the Express Lanes. By contrast, the proportion of their I-85 trips in the general purpose lanes increased from 36% to 81%. In Wave 1, only 17% of their general purpose lane trips comprised two persons; in Wave 2, 52% of their general purpose lanes consisted of 2-persons. This indicates a clear shifting of HOV-2 trips to the general purpose lanes, with a share of 2-person carpools remaining in-tact.

Table 16: Profile of I-85 Trips Among Respondents Making HOV-2 Trips in Wave 1 (based on trip diaries)

	Wave 1	Wave 2
HOV/Express Lanes	64%	19%
General Purpose Trips	36%	81%
1-person	(81%)	(43%)
2-person	(17%)	(52%)
3+ person	(2%)	(5%)
Number of Trips	422	280

Trip Satisfaction

Given the significant shifting of HOV-2 users out of the HOV lanes and onto the general purpose lanes, we sought to explore if there were changes in trip satisfaction across the two waves among this group of carpoolers. For respondents who made any HOV-2 trips in Wave 1, we compared their Wave 1 I-85 trip satisfaction (when a majority of their trips were in the HOV lanes) to their Wave 2 trip satisfaction, when a majority of their trips were in the general purpose lanes. Three measures -- travel time, travel speed and predictability of travel time -- are utilized in this analysis.

On all three measures we see a significant increase in dissatisfaction. With respect to travel time, the level of dissatisfaction among Wave 1 HOV-2 users rose from 39% (combined very dissatisfied, dissatisfied and somewhat dissatisfied) to 48%. Importantly, dissatisfaction became more intense – looking at the bottom two categories only (very dissatisfied and dissatisfied), dissatisfaction grew from 21% to 39%. For travel speed, there is a similar pattern in response; overall dissatisfaction grew from 38% to 49%, with the proportion who were “very dissatisfied” more than doubling (from 9% in Wave 1 to 22% in Wave 2). On predictability of travel time, there is also increased dissatisfaction (from 36% to 45%), though the level of satisfaction declined only very slightly (49% in Wave 1 and 46% in Wave 2).

Table 17: I-85 Trip Satisfaction Among Wave 1 HOV-2 Users: Wave 1 vs. Wave 2 Ratings

	Very Dissatisfied	Dissatisfied	Somewhat Dissatisfied	Neutral	Somewhat Satisfied	Satisfied	Very Satisfied
Travel Time							
Wave 1	10%	11%	18%	10%	14%	28%	9%
Wave 2	18%	21%	9%	9%	16%	23%	5%
Travel Speed							
Wave 1	9%	13%	16%	7%	17%	28%	10%
Wave 2	22%	19%	8%	9%	13%	23%	6%
Predictability							
Wave 1	15%	9%	12%	15%	15%	26%	8%
Wave 2	19%	18%	8%	9%	15%	25%	6%

In addition, we compared the driving experience of Express Lane users across the two waves. We identified all drivers who made an Express Lane Trip in Wave 2 and compared their trip satisfaction in Wave 1 (when nearly all their I-85 trips - 89% - were in the general purpose lanes) with their trip satisfaction in Wave 2 (when a majority of their I-85 trips (72%) were in the Express Lanes). On all three measures of travel time, travel speed and trip predictability, there are significant increases in satisfaction among this group of Express Lane users. One-half or more of I-85 trips were rated as satisfactory in Wave 2 (combined very satisfied, satisfied, and somewhat satisfied), compared to just over one-third of I-85 trips in Wave 1. Moreover, when asked the extent to which they agree that the Express Lanes have improved their travel in the region, 54% of Express Lane users agreed, compared to only 6% of other I-85 users.

Table 18: I-85 Trip Satisfaction among Wave 2 Express Lane Users: Wave 1 vs. Wave 2 Ratings

	Very Dissatisfied	Dissatisfied	Somewhat Dissatisfied	Neutral	Somewhat Satisfied	Satisfied	Very Satisfied
Travel Time							
Wave 1	14%	22%	16%	11%	10%	20%	7%
Wave 2	7%	12%	12%	9%	18%	31%	11%
Travel Speed							
Wave 1	15%	20%	20%	9%	11%	18%	7%
Wave 2	8%	13%	12%	9%	17%	30%	11%
Predictability							
Wave 1	16%	17%	15%	15%	11%	20%	6%
Wave 2	8%	10%	12%	17%	13%	30%	10%

Geography

Geographic differences did not appear to be significant in Atlanta. Figure 3, below, compares the household locations of Peach Pass owners with non-owners. Pass owners appear to be somewhat more likely to live farther from Atlanta and closer to I-85, though that is to be expected. That said, those owners who live farther from the lanes use the Express Lanes for a greater share of their I-85 trips than those living closer to the lanes, as can be seen in Figure 12.

Figure 11: Location Comparison of Peach Pass Owners to Non-Owners

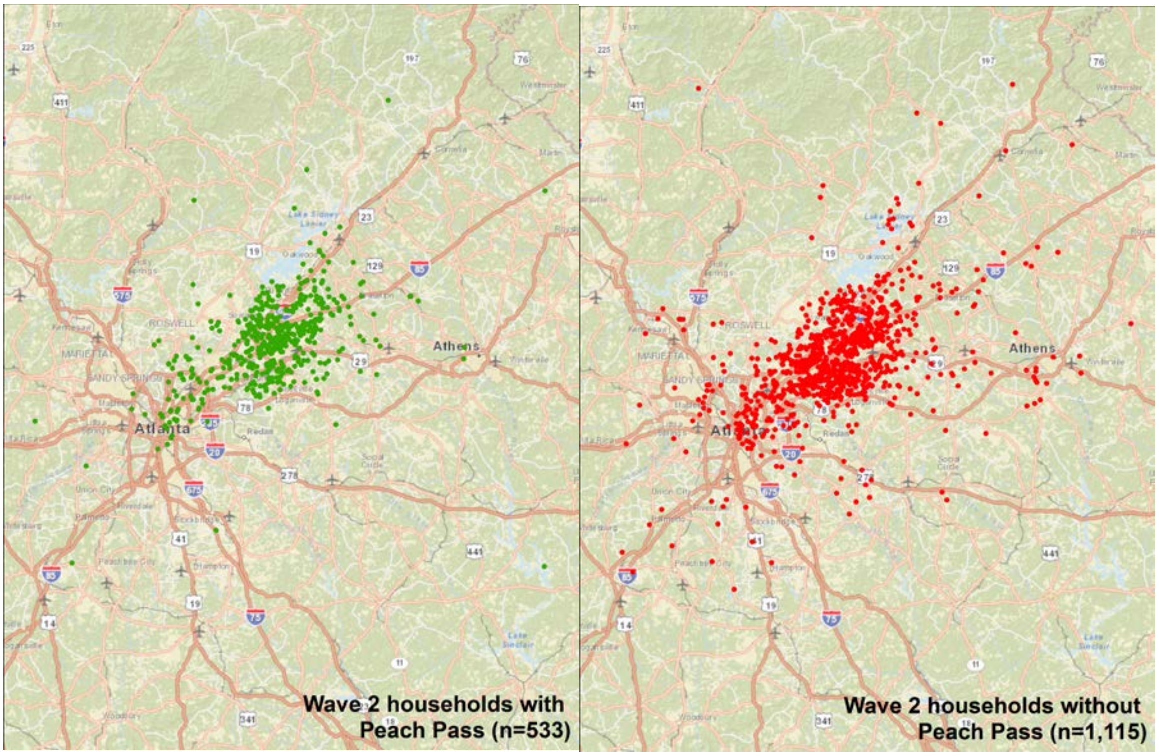
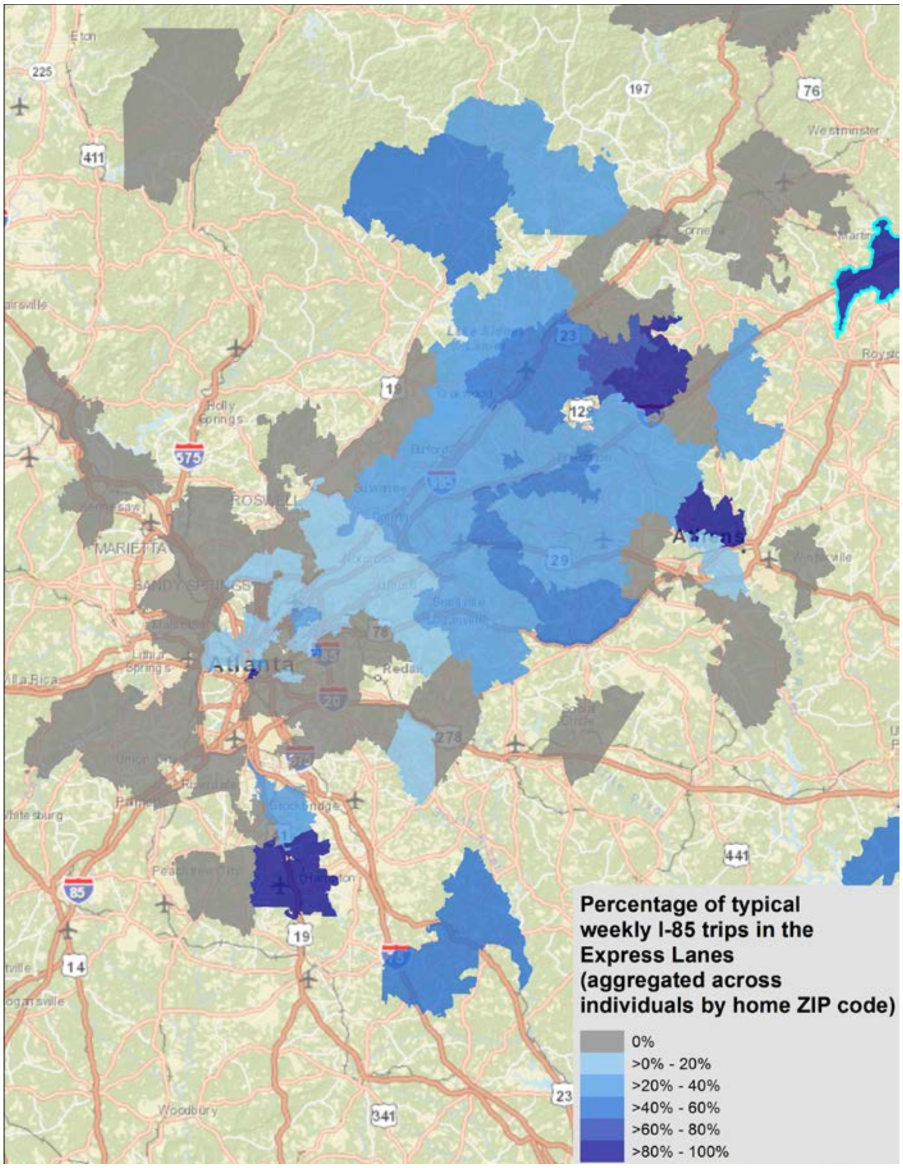


Figure 12: Share of I-85 Trips Made in the Express Lanes by Household Location



Conclusions

The UPA and CRD traveler behavior survey provides the first diary-based study of the impacts of congestion pricing at the household level, including equity impacts. The differences in equity impacts between the two projects highlight the differences in the design (full facility pricing in Seattle and HOT lane pricing in Atlanta) as well as differences in context across the two sites. For the purposes of this paper we analyzed three specific types of equity impact: income, modal, and geographic. The survey findings suggest the following equity implications for regions that are considering the deployment of road pricing.

Income equity impacts are likely to be greatest with full-facility pricing, as compared to an HOV-to HOT lane conversion.

In both Atlanta and Seattle, income was a significant predictor of transponder ownership and higher income respondents were more likely to use the priced facility – findings which align with previous studies. It is worth noting, however, that in both Atlanta on the priced section of I-85 and in Seattle on the SR 520 bridge, drivers had higher than average incomes compared to the region overall.

Particularly in Seattle, the income equity impacts were significant. The lowest income group in Seattle experienced a significantly greater reduction in trips (overall as well as cross-lake), and shifted off of SR 520 more than any other group. More specifically, discretionary cross-lake trips fell by 51% among the lowest income, whereas for other income groups discretionary trips fell by 19% to 27%. Work/school/child care trips across the lake also fell by 34% among the lowest income, which was significantly more than for other groups. That said, because of the context of SR 520 and its location in a higher-income part of the region, income equity impacts may have been less than they otherwise could have been (e.g., if the facility were in a lower income area).

In Atlanta the income equity impacts were relatively small, which makes sense considering the availability of a free alternative adjacent to the new toll lane. While the lowest income group used the priced facility less than higher income groups, the differences were not large, and we did not see a greater cancellation in trips among the lower income.

While users of the priced facility may become more satisfied with their travel as a consequence of improved travel times, this does not necessarily translate into more positive attitudes toward tolling.

Interestingly, we saw very different reactions in in Seattle and Atlanta in their attitudes toward tolling. In Seattle, attitudes became more positive overall, even among the lowest income group, a finding that aligns with previous studies showing that people tend to have more positive attitudes toward tolling once they have had experience with the system. In Atlanta, however, the reverse was the case; opinion became more negative across all income groups, although less so among the wealthiest respondents who made the largest proportion of priced trips. We posit that other contextual factors, such as the purpose of the tolling, familiarity with tolling in the region, the level of public input to the project, and the level of public outreach and education also play a role in influencing public attitudes toward tolling. These factors may help explain the differences in how public attitudes toward tolling evolved in Seattle and Atlanta.

Consider the potential for geographic impacts, particularly when there are limited or highly congested alternative route options to the priced facility.

We found geographic equity impacts in Seattle, as trip satisfaction declined for I-90 trips, and increased significantly for SR 520 trips. Attitudinal measures also clearly revealed that I-90 users perceived a degradation in their travel experiences; fully 55% of I-90 users felt that they were spending more time in traffic since tolling started, compared to only 11% of SR 520 users. Again, context plays a role in explaining these geographic equity impacts. Prior to pricing, both the SR 520 and I-90 bridges were highly congested, especially during peak hours; after pricing, demand shifted away from SR 520, providing faster and more reliable trip times to those who remained and paid tolls, and greater delay for those who had previously been using the I-90 bridge.

Geographic equity did not appear to be a concern in Atlanta, and in part this is due to the nature of the road pricing deployment as well as the context. With the HOV-2 to HOT-3 conversion, the general purpose lanes still remained a free option. Moreover, there are a number of parallel facilities in the corridor that provide other options for travel.

Increased HOV occupancy requirements, combined with pricing, results in less carpool use of the priced facility and greater dissatisfaction among carpoolers, at least in the near-term.

Following the combined introduction of tolling on I-85 and increased vehicle occupancy requirements (from 2+ to 3+), there was a significant reduction in vehicle occupancy in the Express Lanes, as solo drivers became predominant and existing carpools shifted to the general purpose lanes. In terms of modal equity, 2- person carpools perceived the loss of a mobility benefit they had previously enjoyed – access to the HOV-2 lane. In open-ended comments, a number of respondents expressed anger that they could no longer use the HOV lane as a 2-person carpool, and previous HOV-2 users (e.g. those who made trips in the HOV lane in Wave 1) were significantly less satisfied with their trips after the deployment of pricing.

In conclusion, the Seattle SR 520 and Atlanta I-85 tolling projects both had equity impacts. The type and intensity of impact tended to differ as a result of the differences in the design of the pricing strategy as well as differences in the context, including the availability of equivalent route alternatives.

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Appendix A: Additional Tables

Employment Status and Age Profile of Income Groups

Seattle

Seattle Wave 2 Employment Status by Income Group

	Employed full-time	Employed part-time	Self-employed (full or part-time)	Student, not employed or employed <25 hrs/week	Student, employed 25+ hrs/week	Home maker	Retired	Not currently employed	Total (N)
Group 1 (37K)	40%	16%	9%	10%	1%	7%	9%	8%	302
Group 2 (70K)	58%	10%	6%	5%	1%	9%	9%	2%	547
Group 3 (120K)	71%	7%	6%	2%	1%	5%	6%	2%	1,548
Group 4 (200K)	77%	5%	6%	1%	0%	4%	5%	2%	691
Total	**67%**	**8%**	**6%**	**3%**	**1%**	**6%**	**6%**	**3%**	**3,585**

Note: Group 1= 0-3 times the poverty level; Group 2=3-5 times the poverty level; Group 3=5-10 times the poverty level; Group 4=10+ times the poverty level

Seattle Wave 2 Age Breakdown by Income Group

	18-24	25-34	35-44	45-54	55-64	65-74	75-84	85 or older	Total (N)
Group 1 (37K)	7%	24%	23%	19%	19%	8%	1%	0%	302
Group 2 (70K)	5%	26%	23%	20%	19%	6%	1%	0%	547
Group 3 (120K)	2%	22%	27%	23%	19%	6%	1%	0%	1,548
Group 4 (200K)	1%	17%	24%	27%	25%	5%	1%	0%	691
Total	**3%**	**22%**	**25%**	**23%**	**20%**	**6%**	**1%**	**0%**	**3,585**

Note: Group 1= 0-3 times the poverty level; Group 2=3-5 times the poverty level; Group 3=5-10 times the poverty level; Group 4=10+ times the poverty level

Atlanta

Atlanta Wave 2 Employment Status by Income Group

	Employed full-time	Employed part-time	Self-employed (full or part-time)	Student, not employed or employed <25 hrs/week	Student, employed 25+ hrs/week	Home maker	Retired	Not currently employed	Total (N)
Group 1 (44K)	57%	10%	8%	8%	2%	7%	3%	6%	446
Group 2 (75K)	68%	6%	6%	4%	1%	8%	4%	3%	697
Group 3 (113K)	80%	4%	4%	2%	0%	4%	3%	2%	1,158
Group 4 (182K)	79%	3%	7%	1%	0%	4%	5%	1%	232
Total	73%	6%	5%	3%	1%	5%	4%	3%	2,533

Note: Group 1= 0-3 times the poverty level; Group 2=3-5 times the poverty level; Group 3=5-10 times the poverty level; Group 4=10+ times the poverty level

Atlanta Wave 2 Age by Income Group

	18-24	25-34	35-44	45-54	55-64	65-74	75-84	85 or older	Total (N)
Group 1 (44K)	9%	26%	27%	20%	15%	2%	0%	0%	446
Group 2 (75K)	4%	27%	28%	24%	13%	4%	0%	0%	697
Group 3 (113K)	3%	18%	30%	27%	19%	3%	0%	0%	1,158
Group 4 (182K)	1%	10%	18%	35%	31%	4%	1%	0%	232
Total	4%	21%	28%	26%	18%	3%	0%	0%	2,533

Note: Group 1= 0-3 times the poverty level; Group 2=3-5 times the poverty level; Group 3=5-10 times the poverty level; Group 4=10+ times the poverty level

Appendix B: Tabular Data for Figures

Table 8: Table data for Figure 2

	Strongly Disagree	Disagree	Disagree Somewhat	Neutral	Agree Somewhat	Agree	Strongly Agree	N/A
Group 1, (~$37K), W1	3%	8%	3%	13%	12%	22%	37%	2%
Group 1, (~$37K), W2	3%	3%	7%	16%	24%	17%	26%	4%
Group 2, (~$70K), W1	2%	7%	6%	12%	20%	20%	29%	4%
Group 2, (~$70K), W2	3%	5%	8%	16%	18%	20%	25%	5%
Group 3, (~$120K), W1	3%	11%	8%	15%	18%	20%	22%	2%
Group 3, (~$120K), W2	3%	11%	8%	18%	22%	17%	19%	2%
Group 4, (~$200K), W1	6%	13%	11%	17%	19%	18%	15%	2%
Group 4, (~$200K), W2	7%	11%	9%	18%	22%	15%	16%	2%

Table 9: Table Data for Figure 3

	Strongly Disagree	Disagree	Disagree Somewhat	Neutral	Agree Somewhat	Agree	Strongly Agree	N/A
Group 1, (~$37K), W1	12%	14%	10%	12%	19%	21%	8%	6%
Group 1, (~$37K), W2	6%	7%	7%	15%	29%	21%	7%	8%
Group 2, (~$70K), W1	10%	14%	9%	16%	20%	17%	6%	6%
Group 2, (~$70K), W2	8%	8%	8%	13%	25%	24%	9%	6%
Group 3, (~$120K), W1	8%	9%	10%	12%	21%	25%	10%	5%
Group 3, (~$120K), W2	4%	5%	6%	11%	25%	32%	13%	4%
Group 4, (~$200K), W1	8%	7%	8%	9%	19%	29%	18%	3%
Group 4, (~$200K), W2	5%	4%	3%	8%	22%	33%	23%	2%

Table 10: Table data for Figure 6

	Very Dissatisfied	Dissatisfied	Somewhat Dissatisfied	Neutral	Somewhat Satisfied	Satisfied	Very Satisfied
Travel Time, W1	5%	6%	9%	9%	16%	37%	18%
Travel Time, W2	2%	4%	9%	13%	14%	38%	20%
Wait Time, W1	2%	5%	8%	13%	17%	38%	17%
Wait Time, W2	2%	4%	8%	10%	16%	43%	16%
Reliability, W1	3%	3%	8%	8%	18%	39%	21%
Reliability, W2	3%	3%	8%	10%	17%	42%	18%
Seat Availability, W1	4%	4%	9%	7%	12%	42%	23%
Seat Availability, W2	5%	7%	10%	7%	13%	38%	19%

Table 11: Table data for Figure 7

	Very Dissatisfied	Dissatisfied	Somewhat Dissatisfied	Neutral	Somewhat Satisfied	Satisfied	Very Satisfied
Travel Time, W1	9%	13%	14%	14%	13%	25%	11%
Travel Time, W 2	4%	7%	12%	14%	14%	33%	17%
Congestion, W1	10%	14%	14%	13%	13%	26%	11%
Congestion, W2	5%	7%	12%	12%	14%	34%	16%
Predictability, W1	10%	13%	12%	16%	14%	25%	10%
Predictability, W2	6%	8%	10%	13%	14%	34%	15%

Table 12: Table data for Figure 9

	Strongly Disagree	Disagree	Disagree Somewhat	Neutral	Agree Somewhat	Agree	Strongly Agree	N/A
Group 1, (~$44K), Wave 1	5%	7%	6%	11%	16%	23%	28%	4%
Group 1, (~$44K), Wave 2	4%	5%	5%	21%	14%	12%	35%	5%
Group 2, (~$75K), Wave 1	3%	7%	4%	8%	19%	27%	29%	2%
Group 2, (~$75K), Wave 2	6%	8%	6%	17%	14%	14%	31%	5%
Group 3, (~$113K), Wave 1	4%	9%	4%	7%	19%	24%	30%	3%
Group 3, (~$113K), Wave 2	9%	10%	6%	15%	13%	15%	29%	3%
Group 4, (~$182K), Wave 1	5%	7%	6%	7%	16%	21%	34%	3%
Group 4, (~$182K), Wave 2	11%	16%	7%	21%	8%	10%	26%	2%

Table 13: Table Data for Figure 10

	Strongly Disagree	Disagree	Disagree Somewhat	Neutral	Agree Somewhat	Agree	Strongly Agree	N/A
Group 1, (~$44K), Wave 1	6%	7%	6%	14%	14%	21%	26%	5%
Group 1, (~$44K), Wave 2	18%	16%	6%	14%	12%	17%	9%	7%
Group 2, (~$75K), Wave 1	5%	12%	8%	11%	17%	17%	28%	3%
Group 2, (~$75K), Wave 2	23%	11%	6%	15%	15%	16%	8%	6%
Group 3, (~$113K), Wave 1	5%	12%	7%	10%	17%	19%	29%	2%
Group 3, (~$113K), Wave 2	21%	15%	7%	12%	13%	16%	11%	6%
Group 4, (~$182K), Wave 1	6%	12%	8%	9%	17%	19%	28%	3%
Group 4, (~$182K), Wave 2	19%	12%	5%	9%	17%	19%	16%	2%

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