The Impacts of Tolling on Low-income Persons in the Puget Sound Region

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THE IMPACTS OF TOLLING ON LOW-INCOME PERSONS IN THE PUGET SOUND REGION

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16. ABSTRACT

To improve our understanding of how tolling is likely to affect low-income populations in the Puget Sound region, this report accomplishes four objectives. It

1. reviews existing research on the impacts of tolling on low-income households in the United States
2. assesses the usefulness of currently available Washington and Puget Sound data for estimating the impacts of tolling on low-income populations
3. develops a preliminary estimate of the impacts of tolling on low-income populations living in the Puget Sound region
4. suggests data collection and methodological strategies for future research that would yield better estimates of the impacts of tolling on low-income populations in the Puget Sound region and other parts of Washington state.

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2. assesses the usefulness of currently available Washington and Puget Sound data for estimating the impact of tolling on low-income populations.
3. develops a preliminary estimate of the impact of tolling on low-income populations living in the Puget Sound region.
4. suggests data collection and methodological strategies for future research that would yield better estimates of the impact of tolling on low-income populations in the Puget Sound region and other parts of Washington.

Objective 1. Existing Research

There is limited research on the main factors that determine tolls' equity impacts. These factors are car ownership, employment, behavioral responses to tolls, and post-toll use of roads and bridges. Key findings from prior studies we reviewed are:

- Equity impacts are always project and region specific.
- Poor households differ in car ownership, employment, commuting needs and use of non-car modes of travel. Thus, tolls' impacts differ among poor households. The literature does not examine such differences empirically.
- The financial costs of tolls are regressively distributed. The regressivity increases when time savings are taken into account.
- Use of toll revenue is a key determinant of whether poor persons, on net, gain or lose from a tolling regime.
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- Using tolls to finance a project will generally impose fewer costs on the poor than using broad based consumption-oriented taxes such as the gas tax.

- To have a full picture of the equity effects of tolling, one must compare those effects to the effects of an alternate financing method in a no-toll scenario.

Since prior studies use an income higher than the official poverty line to identify poor households, their findings may not fully apply to officially poor households.

Objective 2. Usefulness of Current Data

We assessed the 2007 American Community Survey (ACS), the Washington Population Survey (WaPop) for 2004 and 2006, and the Puget Sound Regional Council's 2006 Household Activities Survey (HAS). The ACS provides the best information about income, employment, car ownership, and commute modes. The HAS is valuable because it allows us to generate specific information about current travel routes of poor and non-poor households. The WaPop is much less useful because its sample of each county's residents is not representative of the county population.

Objective 3. Estimate of Tolling Impacts

Based on the background knowledge from the literature review and the capacity of the best available data, we conducted original empirical research. We created a new geographic specific route-based analysis to determine the distribution of current highway use and used these findings to project impacts of hypothetical tolling regimes.

A smaller percentage of the poor than the non-poor are likely to be affected by tolling in the Puget Sound region. The poor are less likely than the non-poor to commute in a personal vehicle and more likely to commute using public transportation or other modes that would not be subject to tolls. Among commuters, the poor are less likely to use highway routes that may be tolled.

We use these findings to project the financial impact of two hypothetical tolling regimes. The first imposes a one-way toll of $2 on 12 major highway segments in King County. Across all households - whether or not they commute on tolled segments - the average annual cost of such a plan for households at the poverty line would be $772 or 4.4 percent of income and, for households with the median income, $1,266 or 1.8 percent of income. For households that drive on one or more tolled segments, the average cost is much higher—about $2,600 per year for both poor and non-poor households. Such tolls would absorb 15.2 percent of a poor household's income, or about four times the rate for a non-poor household. Non-users, of course, would pay nothing. Devoting 15 percent of income to tolls would force large reductions in other types of expenditures and, thus, substantially reduce the economic well-being of poor households whose workers commute in private vehicles.

The second regime imposes a $2 one-way toll only on the SR 520 bridge. The small number of poor households that use the bridge would pay $960 per year, or 5.5 percent of income. The corresponding small set of non-poor households would also pay $960, which would equal 1.4 percent of their income. The costs of tolls would certainly reduce the economic well-being of poor users of the SR 520 bridge.

The study has several important limitations. Estimates based on the HAS are imprecise because its sample of poor households is small, and we could not estimate possible time savings due to tolls. Our projections assume a toll that does not vary by time or day nor provide a non-tolled option. The level and distribution of the costs of congestion tolls or HOT lane tolls with adjacent free lanes would surely differ. Our estimates are based on current commuting patterns and do not take into account tolls' effects on travel mode, choice of route, or other relevant behaviors. These limitations call for caution in interpreting the findings and drawing policy conclusions from them.

Objective 4. Future Research

To better estimate tolls' impacts on low-income populations in Puget Sound, future research needs to collect more or slightly different information from existing ongoing surveys. Emphasis should be placed on oversampling poor households and obtaining high quality data on income and home and work locations.

In addition, conducting a randomized field experiment could better identify how regional travel patterns are likely to change in response to tolls. Such an experiment would be a major undertaking with the potential to significantly advance knowledge about responses to tolling regimes.

Section 1: Introduction and Background

Washington State is actively considering placing tolls on roads and bridges as part of a strategy for funding transportation improvements. To do so in compliance with federal law and policies, the state needs to understand how tolling is likely to affect its low-income populations. This report intends to improve our understanding of how tolling is likely to affect low-income populations in the Puget Sound area, especially in King County. Future studies could build on this report to analyze similar issues for other regions of the state.

Background

Tolls on highways and bridges could increase funds for construction and maintenance of transportation infrastructure, and reduce congestion and air pollution by giving residents incentives to use the highway system more efficiently. Tolls generally take two forms. Flat rate tolls remain constant throughout the day (though they may vary by type of vehicle). Time-varying (congestion) tolls impose higher rates when traffic is heavy, and lower rates during off-peak times. Time-varying tolls may change on a well-defined schedule—for example, a constant high rate during 6:00-9:00 a.m. and 4:00-7:00 p.m. on weekdays and a constant lower rate at all other times. Or they may vary in response to real time changes in traffic volume. Current tolls in Washington State include a flat toll on the Tacoma Narrows Bridge and a time-varying HOT lane (High Occupancy Transit) toll scheme on SR 167. Future tolls Washington State may be for the purpose of managing congestion, hence varying according to traffic volume, or may be solely to raise revenue.

Understanding the socio-economic impacts of tolls requires information on several key issues:

1. How will poor and non-poor households use the transportation facilities after a toll is imposed? One would expect post-toll patterns of use to differ from the pre-toll patterns because, for example, a toll may induce some drivers to change routes, start carpooling, switch to public transit, or shift use of tolled

facilities to non-peak periods. Some drivers, though, may not change behavior at all.

2. How would tolls affect the economic status of poor and non-poor households on average? Are some sub-groups among the poor likely to pay significantly more tolls than others?
3. For residents who choose to use tolled routes, how much time will they save? For those who would use non-tolled routes or shift to public transportation or car pools, how much extra time will they spend in travel?
4. How will the potential behavioral changes differ, on average, by income status? Will some sub-groups among poor populations make large changes in behavior, while others will be largely unaffected?

Not all of these items can be reasonably estimated given currently available knowledge and data. To foreshadow our results, we generate empirical analysis about potential economic costs of tolling, which directly addresses the questions in item 2. above. Specifically, we estimate the cost of tolls to poor and non-poor households based on new information about current travel routes. Our review of the literature suggests that there is not a good, generalizable understanding of how households react to tolls (items 1 and 4 above). Hence our estimate is static in that it does not consider potential behavioral changes. Available data do not provide good estimate of route-specific commute times, meaning that any estimates of time savings would involve significant conjecture. For this reason, we also do not generate estimates of changes in commute times (item 3).

Objectives

This report has four objectives:

1. It comprehensively reviews existing research on the travel behavior of and impact of tolling on low-income households in the United States, including the limited studies of impacts on low-income households living in the Puget Sound area.
2. It assesses the usefulness of currently available Washington and Puget Sound data for estimating the impact of tolling on low-income populations.

3. It develops a preliminary estimate of the impact of tolling on low-income populations living in the Puget Sound region.
4. It suggests data collection and methodological strategies for future research that would yield more detailed and precise estimates of the impact of tolling on low-income populations in Washington and the Puget Sound region.

Section 2 reviews the literature on how tolls affect equity. We examine what is known about tolls' impacts on the financial status and driving time of poor households, and on poor households relative to middle and high income households. The studies discussed in section 2 all use an income higher than the official poverty line to distinguish poor from non-poor households. Consequently, section 2 uses the terms "poor" and "low-income" as defined by each study's author, not by the official poverty measure.

Section 3 assesses the usefulness of currently available data for estimating the impact of tolling on King County's poor households and finds important limitations. Given these limitations, section 4 presents statistical analyses of King County households and their driving patterns that shed light on the likely impact of local bridge and highway tolls on both poor and non-poor households. Unlike the studies discussed in section 2, these analyses use the official poverty measure to delimit poor from non-poor. Section 5 summarizes data collection and methodological strategies that could yield more accurate, detailed estimates of the impact of tolling on poor populations in the Puget Sound region.

Section 2: Literature Review (Objective 1)

The concept of congestion pricing goes back as far as Pigou's *Wealth and Welfare*, published in 1920. Equity was not seriously considered in the literature spawned by Pigou's work until Vickrey's (1963) article "Congestion Charges and Welfare." Since then, equity has become an important part of the debate about the appropriate use of tolls.

Equity in transportation has multiple dimensions. Weinstein and Sciara (2004) report that income equity was the most frequently heard concern, and other important facets of equity were geographical, modal and gender. Giuliano (1994) emphasizes that the "Impacts of congestion pricing are not necessarily related to income." and maintains that gender and occupation are important factors in determining if a traveler has the flexibility to change behavior in response to a toll. Ungemah (2007) contends that congestion pricing involves five types of equity concerns: geographic, income, participation, opportunity, and modal. Of the five, he argues that income and geographic are the most important, as they incorporate elements of the other types.

This review examines research findings on the income equity of both congestion tolls and constant (time invariant) tolls, especially as they affect poor households.

Assessing the income equity of a tolling regime requires analysis of three sets of related issues. First what are the regime's likely financial and time impacts on poor households? Such impacts include how much a typical low-income household would spend on tolls over a month or year, the share of its income spent on tolls, and how this spending might affect consumption of other goods and services. The time impact concerns how much travel time low-income households generally save because of congestion tolls or whether their travel time would tend to increase as they shift to non-tolled but longer or more congested alternative routes, or to public transportation. These figures are of interest regardless of whether one can estimate similar impacts for middle and high income households.

Second, what are the financial and time impacts for poor households relative to those for middle and high income households? One might examine whether poor households would be disproportionately affected in the percentage of income spent on tolls or in time savings. One might also examine whether the payment methods, deposits, and service fees required by transponder programs curtail poor households' access to a transportation facility relative to other income groups.

Third, what would be the likely distribution of toll expenditures and time costs and savings among different types of poor households**?** Would some types pay more tolls than others? Would some save more travel time or face larger increases in travel time?

Answers to these questions will always be project-specific because they depend on the facilities subject to tolls, whether constant tolls or congestion tolls are imposed, the amount of the toll (for congestion tolls, how the amount changes), other relevant attributes of the specific tolling regime, and the demographic characteristics of the region affected by the regime. For any specific project, several important factors need to be examined:

- The rate of car ownership among low-income households, since car owners will be most strongly affected by tolls
- The level of employment among low-income households since commuting travel is most likely to be tolled
- Post-toll use of transportation facilities by poor and non-poor households. A toll may induce some drivers to change routes, switch to public transit and carpools, or drive less. For congestion tolls, drivers might also shift driving to off-peak times, choose to use non-tolled lanes where this is an option, or possibly start using the less congested tolled route because of the time savings. Some drivers may not change behavior at all. Such changes will affect who ultimately uses the tolled facilities.

Sections 2a, 2b, and 2c summarize the literature about these factors.

To estimate a specific tolling project's equity impacts, one needs to combine information on these three factors with project-specific data on the pre-toll travel patterns of poor and non-poor households and the pricing structure and collection mechanism of tolls.[1] A number of empirical studies have done so to provide estimates of specific

1 Characteristics of pricing and the collection mechanism include whether the toll is constant or time varying, whether low-income users will pay less to use the facility, and whether they will receive financial assistance to purchase transponders.

tolling projects' impacts on the low-income population, including the relative impacts and how impacts differ among types of poor households. Section 2d reviews this research.

Because roads are funded and tolls collected within larger public budgets, a more complete analysis needs to consider how toll revenues are used and how much the uses benefit poor households. Section 2e reviews research on this issue.[2] Section 2f provides summary broad observations and conclusions from the review.

We observe that every study uses an income higher than the official poverty line to distinguish poor from non-poor households. Because of small sample size, in some studies the lowest income category extends well into the lower-middle and middle class. Consequently, the discussion of each study uses the terms "poor" and "low-income" as defined by its author, not by the official poverty measure.

2a. Car Ownership among the Poor

An important factor in how tolls would affect low-income households is how often they would use the facility, which depends to an important degree on their rate of car ownership. Pucher and Renne (2003) use the 2001 National Household Travel Survey to examine the travel patterns of low-income households (incomes below $23,000 in 2006 dollars). They report that rates of car ownership increase with income. More than 26 percent of low-income households do not have a car, compared to only 5 percent of the households in the next income level and less than 2 percent of households making more than $114,000 (2006 dollars). "A car is one of the first major purchases households make as soon as they can, even if it strains their limited budgets. It is probably unique to the United States that three-fourths of even its poorest households own a car." Among low-income households that own cars, 65 percent have one, 24 percent have two, and 10 percent have three or more (computed from Pucher and Renne, Table 6).

Even households with no car report considerable auto use (34 percent of all trips in 2001). For most of their trips, they are passengers in someone else's car. Roughly

[2] The review does not consider other notions of equity (e.g., geographic, gender) or the impact of tolls on variables such as environmental quality, safety, property values, and commercial activities.

three-fourths of all trips made by the poorest households are by car. Only 4.6 percent of all trips by low-income households use any type of public transit.[3] [4]

Differences in car ownership among poor households suggest that the financial and time impacts of tolls will not be borne equally among the poor. Poor households without a car will pay less than households with one who, in turn, will pay less than those with two.

Section 4 of the report provides recent data on car ownership among poor and non-poor households in King County.

2b. Employment among the Poor

Because tolls are most likely to strongly affect commuting travel, the financial and time impacts of tolls will depend on whether a household has one or more employed members. The many studies of employment among the poor show that most poor households contain at least one employed member, but the percentage with workers is lower than for non-poor households.

Like differences in car ownership, differences in employment among poor households imply that the impacts of tolls will not be borne equally. With congestion tolls, poor workers who drive will face financial costs but will save time. Poor workers who already use public transit will save time without paying the toll. Those who switch to public transit will avoid the toll but may incur higher time costs. Workers who rely on cars and choose to bypass tolled facilities will spend more time commuting. Poor households in which all employed members currently choose less common modes of commuting (e.g., walking) will be largely unaffected by tolls. Poor households without

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[3] In the Puget Sound region, transit use by the poor is much higher – 18.5 percent (see Table 1 in section 4).

[4] Murakami and Young (1997), an early, frequently cited study, uses the 1995 National Personal Transportation Survey to examine the travel patterns of low-income households. The study finds that 74 percent of low-income households have a car and over 84 percent of their trips to work are made in private vehicles. Ownership varies by family structure—64 percent of low-income single parent households own cars, compared to 79 percent of other low-income households. On average there are 0.7 vehicles per adult in low-income households, compared to more than 1 vehicle per adult in other households. Average vehicle occupancy and time to work for low-income and non low-income households commuting to work by private vehicle did not differ significantly. Low-income individuals were more likely to walk to work (6 percent vs. 3 percent) and to use public transit (5 percent vs. 2 percent) than their non-poor counterparts.

workers will neither pay tolls for commuting nor save time.[5] Such households are likely to disproportionately include elderly and disabled persons.

Studies of employment differences among the poor have not considered their findings' implications for the impact of tolls, while studies of tolling have generally not distinguished between households with and without workers nor examined the relationships among employment, poverty and local travel choices. Instead of reviewing the paucity of relevant published information, we have generated information about employment among poor and non-poor households in King County. Section 4 provides these data as part of its analysis of the equity impacts of tolls.

The research discussed in section 2a and this section shows there are substantial differences among poor households in car ownership, driving patterns, employment, commuting needs and use of non-car modes of travel. This implies that the financial and time impacts of tolls are not borne equally among poor households. The literature does not, however, contain estimates of differences in net benefits (costs) among subgroups of the poor.

2c. Post-Toll Use of Transportation Facilities

This section discusses the research evidence pertinent to determinants and patterns of post-toll travel behavior. Pre- and post-toll travel patterns will differ since tolls encourage residents to change their behavior (e.g., using non-tolled routes, shifting use of tolled facilities to non-peak periods, shifting from private cars to public transportation or car pools).

Tolls of any kind increase the costs of using certain travel routes or modes. Poor households who have been using those routes or modes can reduce tolls' impact on their budgets by changing their travel behaviors. For instance, they might use non-tolled routes or lanes to avoid payment, shift use of tolled facilities to non-peak periods (for congestion tolls), shift from private cars to public transportation or car pools, take fewer trips overall, or some combination of these or other adaptations. Over the longer term, some may switch to jobs that do not require a daily commute on tolled facilities. Some

[5] This assumes they do not drive during congested times. They probably will pay to drive on facilities during non-congested times because congestion pricing typically lowers the price during non-congested times but does not eliminate it.

poor drivers will choose to pay the tolls because they conclude that the benefits of the time savings exceed the cost of the toll, they need to use their vehicles on the job, or have no other viable option.

Harvey (1994) uses examples of demand elasticities taken from real world transportation scenarios—ranging from bridge toll increases to parking fee increases, to transit fare increases—to argue that travelers adjust their behavior in response to price. He states that "even the most rigidly constrained worker retains some freedom to shift the conditions of travel to avoid an onerous price." The behavioral response to a specific toll will depend on: How income is distributed among affected travelers, how much it costs to travel, the before-toll travel and patterns, how much alternative routes would increase time for commuting and other trips, and the availability and quality of alternative modes of transportation.

The PSRC’s Traffic Choices Study (2008), a pilot project that tested how travelers in Seattle change behavior in response to a variable charge for road use, found that many households made notable changes in their travel behavior. There was less responsiveness to price for higher income households than for lower income households. Higher income households would pay more in tolls, while lower income households would mainly pay in terms of time and convenience by switching modes or times of travel, or by reducing the numbers of trips. The small number of households below the official poverty line in this study limits our ability to draw conclusions.

Sullivan's (2000) analysis of congestion tolls on California SR 91 notes that despite a price increase, usage remained steady among both the lowest income group (under $40,000) and the highest income group (over $100,000). Usage in the middle income group ($40,000–$60,000) declined from 40 percent to 25 percent. Sullivan suggests that middle-income persons are more price sensitive than lower-income persons, perhaps because they have more flexibility with their time.

The above studies use data from congestion pricing projects to derive their findings on behavioral responses. It is reasonable to extrapolate the general findings to constant tolls since both types of tolls change the relative cost of different travel routes and modes.

2d. Empirical Findings on How Tolls Affect the Economic Well-Being of the Poor

This section discusses the research evidence pertinent to the second, third and fourth sets of questions on pages 2 and 3, which concern who pays the tolls, how tolls affect driving times on both tolled routes and non-tolled alternatives, and how these impacts vary within and across income groups.

Tolls may be progressive, regressive, or neutral, depending on the social and geographic characteristics of the town or region and the structure of the tolling regime. The distributional effects must be evaluated on a site and project specific basis (Santos and Rojey 2004, Elliasson and Mattsson 2006, Prozzi et al. 2007).

According to Richardson and Bae (1996) and Giuliano (1994), the major stylized facts about the income equity effects of tolls in the United States are:

1. High income drivers tend to benefit because they value their time more than the increased cost of driving.
2. Low-income drivers and those who react to tolls by no longer using the tolled routes suffer losses.[6]
3. The net distributional effects of congestion tolls depend on how the revenues they generate are used.
4. A well designed revenue redistribution can result in gains for all income classes, but some low-income individuals are still likely to lose under any broad redistribution, such as those who cannot change their commute patterns to take advantage of improved transit.

A rigorous, thorough assessment of these distributional effects requires complex data and highly sophisticated modeling of households' potential behavioral responses to a specific tolling regime (Giuliano 1994). Since no study fully meets these requirements, one instead must identify the consensus of the major extant studies and assume it reasonably approximates the "truth."

[6] Elliasson and Mattsson (2006) similarly conclude that tolls are most likely to be regressive in situations where cars are widely used by both high and low-income individuals and low-income people have few alternatives in their modes of travel, and less flexible work schedules. This, they observe, is often the case in American cities. They suggest that tolls may not be regressive in European cities, where transportation options and the residential locations of rich and poor generally differ from the American situation.

This section discusses the evidence for the first two stylized facts. Section 2e discusses the equity effects of the use of revenues.[7]

Small (1983), an important early study, modeled the equity effects of three hypothetical optimal peak expressway tolls. The level of each toll (about $1.25, $4.50, and $10.00 per day in 2005 dollars) was based on the assumed degree of congestion in the absence of the toll. Data for drivers in the San Francisco Bay area showed that when the toll's financial cost <u>and</u> the value of time savings from less congestion are both counted, the lowest income group ($0-46,000 in 2005 dollars) has the largest absolute losses. Net benefits were inversely related to income for all three tolls.

Drawing on Small's (1992) assumptions regarding income, value of time and other relevant variables, Giuliano (1994) showed that under a hypothetical peak period vehicle miles traveled fee of $0.15 per mile in the Los Angeles region, low and middle income commuters would accrue benefits if they could change their mode of travel to avoid a toll. Otherwise, they would lose. In other words, whether they benefited from a congestion pricing policy depended on their current mode and their flexibility to change that mode. This study computed net benefits for specific types of commuters, rather than for a representative sample of commuters. Thus, it cannot estimate the average net benefits for all poor commuters (or for all commuters in other income classes) nor examine differences in net benefits among the poor.

Based on 5 years of field observations of California's SR 91 express lanes, Sullivan (2002) reports that use of that tolled facility is positively correlated with income. Use is also positively correlated with perceived time savings, which implies that, controlling for the amount of time saved, drivers who place the highest value on their time will be more likely to use the facility. Since those with higher value of time tend to have higher income, the two correlations are consistent with each other.[8] Though some studies have suggested that drivers with the most inflexible work schedules, who are likely to be disproportionately poor, would be obliged to use a tolled facility, Sullivan

[7] Unfortunately, none of the studies discussed here reports results for poor persons or households as defined by the official poverty measure.

[8] Similarly, in a study of San Diego's I-15 congestion pricing project, Supernak et al. (2002) find that express lane users are more likely to be from higher income households than non-users.

found that work schedule flexibility, or lack thereof, appeared to be unrelated to SR 91 express lane use.

Pucher and Renne (2003) provide useful descriptive information on urban travel patterns from the 2001 National Household Transportation Survey. They find that differences among income groups in average length of trip by car and time of day of car travel are not large. Based on this information, the authors conclude that vehicle miles traveled fees, roadway tolls, and peak-hour tolls would be regressive since the payments would be a much higher percentage of poor households' incomes. Poor households take fewer trips, which would lower their relative burden from potential tolls, but substantial regressivity would still exist.

While the study's conclusion accords with the literature, it assumes no behavioral response to tolls. It also does not distinguish between households with commuters from those with no members in the labor force. Unlike the other studies discussed here, it does not take time savings into account and does not either examine data on the incomes of actual users of tolled facilities or use a simulation model to assess the equity effects.

Safirova et al. (2003) analyze the equity effects of a hypothetical conversion of several HOV lanes in northern Virginia to High Occupancy Transit lanes. They conclude that all income groups would benefit from the conversion. Wealthier drivers receive net benefits that are 27 times greater than those received by drivers from the poorest quartile. This difference largely reflects the higher value that wealthier drivers place on their time.[9]

In a related study, Safirova et al. (2005) examine the relative merits of cordon tolls and link-based tolls, using Washington DC as a test case. They conclude that both can provide a net benefit to users. However, this net benefit is not realized until after revenues are used to pay for roads or other public goods. Before revenue recycling, the net change in well-being under either toll is negative. Both policies result in net welfare losses among the lowest income quartile and some losses to the second poorest quartile.

The Texas QuickRide project on the Katy Freeway in Houston is a variation of a HOT lane in which HOV+2 users may pay a fee ($2.00, 1998 dollars) to access an

[9] D.C. metro area drivers outside the geographic area where the HOT lanes are implemented bear welfare losses. The study does not provide a distributional analysis of those losses.

otherwise HOV+3 and transit-only lane. Burris and Hannay (2004) found that in 1998 the vast majority of users and non-users had household incomes of at least $50,000. About 13 percent of users had incomes below $50,000 compared to 23 percent of non-users, which suggests that less affluent households benefit less. Among users, average usage per week of QuickRide lanes was not significantly related to income. However, because of small sample size, only two very broad income groups (less than $75,000 and $75,000+) could be compared. The small sample size also meant that the study could not compare use between low-income persons (say, $0-20,000) and others.[10]

Franklin (2007) provides the most sophisticated analysis of the equity effects of a hypothetical toll. He applies his methodology to a specific project by analyzing a hypothetical $3.00 toll to cross the SR 520 bridge during the morning commute into Seattle. In comparing the equity effects with and without a lump-sum redistribution to all commuters, he finds that the toll itself was regressive. The effect of the toll was made even more regressive when time travel savings were taken into account, because of the higher value placed on time by the higher income drivers.[11]

Gomez-Ibanez (1992) develops a useful characterization of the winners and losers under a congestion pricing policy on an already existing road. Winners include: 1) solo drivers who gain because of time savings that, for them, offset the toll, 2) HOV drivers or public transit users who continue to use the HOV lane and benefit from improved speeds, 3) recipients of toll revenues, if distributed. Losers are: 4) solo drivers for whom the time savings is valued less than the toll, but who do not have the flexibility to change their route, 5) those who switch to a less convenient route to avoid the toll, 6) those already using the alternative route who experience more congestion, and 7) those who decline to make the trip because of the toll. An eighth group, those who switch to HOV or transit to avoid the toll, may either win or lose, depending on whether the time and money savings

[10] Only 12 percent of non-users cited price as the reason for not participating in the program, but the study did not compare the mean income of these non-users to the mean income of the other 88 percent.

[11] Franklin relied on measures of income inequality to reach his conclusions. He does not show impacts on separate income classes or poor households.

from switching modes exceed the inconvenience.[12] Because winners and losers would inevitably include persons in all income groups, it is difficult to talk about the progressivity or regressivity of tolling without reference to a specific tolling project and location. Gomez-Ibanez, though, does not present an actual estimate of the distributional effects of a specific tolling regime. [13]

Equity impact studies typically assume that individuals' value of time increases as their earnings increase. However, data for King County suggest that some poor persons also place a relatively high value on their time because they have less flexible work schedules than many middle and upper income workers, must punch a time clock, or for other reasons. If this is the case for significant numbers of poor households, estimates using the standard assumption will overstate the regressivity.

Equity of access to tolled facilities. Parkany (2005) examines whether highway and bridge tolls affect equity of access to the tolled facilities. She concludes that the paperwork, payment methods and deposits required by transponder programs present a significant obstacle to low-income individuals' access to tolled facilities because those persons are less likely to have credit cards or bank accounts. She notes that income has a positive effect on toll road use, frequency of use, and transponder ownership.

The Texas QuickRide program may provide an example of this obstacle (Burris and Hannay 2004). Enrolling in it required a credit card, a $15 transponder deposit, and a $40 prepaid account. Once the account balance reached $10, the credit card was charged to bring the balance back to $40. A $2.50 monthly service fee was also charged for each transponder. Burris and Hannay (2004) speculate that these costs, on top of the $2 toll deducted from the account each time a transponder entered a tolled facility, may have made QuickRide prohibitively expensive for some low-income drivers.

[12] Giuliano (1994) suggests that high income persons are likely to be in group 1 (winner), low-income persons are likely be in groups 2 and 3 (winners), and middle income persons would probably be in groups 4, 5, and 7 (losers).

[13] In addition to these studies, the theoretical analysis in Arnott et al. (1994) implied that because wealthier drivers value time more highly than poorer drivers, congestion tolls tend to benefit the rich and hurt the poor. The study did not conduct an empirical test of the theory or analyze the extent to which various uses of the revenue might offset the direct effects of the tolls. Findings by Small, Safirova et al., Giuliano and Franklin are consistent with the theory.

2e. Revenue Use

While there is some disagreement about the extent to which tolls would negatively affect low-income drivers, analysts generally share the view that negative impacts could potentially be offset by using revenues in ways that benefit the poor. The Traffic Choices Study (2008) notes that toll revenues could and should be used to address equity concerns and states "…the most distinctive feature of road pricing is that pricing generates revenues that can be used to directly address any issues of fairness." Santos and Rojey (2004) similarly conclude: "The way in which government allocates revenues will determine both the equity and the political acceptability of a road pricing scheme." Safirova et al. (2005) and Eliasson and Mattsson (2006) make the same point.

Though these observations are valid, in practice Washington and other states are most likely to fully devote toll revenues to the construction, improvement and maintenance of tolled facilities and, if funds suffice, other transportation projects (Franklin 2007, Richardson and Bae 1996, Weinstein and Sciara 2004). Hence, when assessing the equity effects of tolls, researchers should generally assume that no revenue will be available to offset any undesired equity effects. Appendix A provides a summary of findings from studies of revenue use for readers interested in this issue.

<u>Tolls versus alternative funding sources.</u> A little-studied topic in the literature considers how using tolls to finance a project compares to using other revenue sources in terms of their effects on poor households. A common perception is that low-income households will disproportionally bear the costs of tolling schemes. This implicitly assumes that poor households would not otherwise help pay for the tolled facilities. This assumption is not correct (Schweitzer and Taylor 2008). In Washington state, if tolls do not finance construction and maintenance of specific highways and bridges, gas taxes and vehicle and user fees will provide the funding.

It is widely recognized that consumption taxes, such as the gas tax, are regressive—they take a larger share of poor households' incomes than of non-poor households'. To have a full picture of the equity effects of tolling, one must compare those effects to the effects of an alternate financing method in a no-toll scenario (Franklin 2007, Weinstein and Sciara 2004).

There are no studies that compare the distributional impacts of toll revenues to the same total revenue raised via a gas tax. Schweitzer and Taylor's (2008) excellent analysis, though, compares the distributional impacts of congestion tolls and a sales tax. Since sales and gas taxes have similar distributional effects, the findings are suggestive of the difference between congestion tolls and a gas tax.

Using the funding of California's SR 91 HOT lanes project as a case study, Schweitzer and Taylor (2008) find that the sales tax spreads the costs to more people and does so in a regressive way. Low-income households (median income = $7,100 in 2003 dollars) do not pay the tolls because they seldom use the tolled lanes and tend to do so when they are free. Under the sales tax scenario they would pay $3.4 million of the project's total cost of $34 million, or $67 more per family than under a tolling scenario. The most affluent families also would pay more with a sales tax, but only $27 per family. With a sales tax the middle three income groups would pay less per family. In addition, raising revenues via the sales tax shifts the costs from users, who benefit from the facility, to non-users. The overall result is that lower income households, on average, are worse off than if congestion tolls funded the SR 91 project.[14] This study's methods can be replicated for other transportation projects to compare the impacts of different financing arrangements on poor households.

Schweitzer and Taylor (2008) also estimate the gains and losses to different types of households within each income class. Among low-income households, shifting from tolls to sales taxes is financially neutral for heavy, moderate and infrequent HOT lane users during both peak and non-peak periods. The extra burden of a sales tax falls entirely on low-income <u>non-users</u>.

Observations and Conclusions

We offer several observations and conclusions based on this review of the research literature.

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14 The article also observes that because sales taxes are independent of persons' driving choices, they do not give persons a price signal when making transportation choices which, in turn, creates more incentive to drive. Much earlier, Richardson and Bae (1996) called attention to the idea that financing public infrastructure through tolls could be more progressive than providing nominally free highways paid for by federal and state gasoline, sales, and property taxes. They did not provide careful empirical evidence to support this argument.

- There is limited research on the main issues examined in this review: car ownership and employment among the poor (sections 2a and 2b), behavioral response to tolls (section 2c), and tolls' equity impacts on poor households and on poor households relative to middle and high income households (section 2d). Transportation planners and policy makers need a stronger research base to inform their decisions, especially with the environmental justice issues raised by transportation projects.
- The paucity of studies is not too problematic for our needs because equity impacts are always project-specific. They depend on the facilities subject to tolls, the price structure and other relevant attributes of the tolling regime, transportation alternatives to the tolled facilities, and the demographic characteristics of the region affected by the regime. Thus, we should not extrapolate findings from extant studies to estimate impacts for Seattle, King County and the Puget Sound region (with the exception of Franklin, 2007). We can, though, draw on their research methods to estimate tolls' local impacts.
- The literature shows there are substantial differences among poor households in car ownership, driving patterns, employment, commuting needs and use of non-car modes of travel (sections 2a and 2b). This implies that the financial and time impacts of tolls are not borne equally among poor households. The literature does not, however, contain estimates of differences in net benefits (costs) among subgroups of the poor. Providing information on this issue should be part of the future research agenda.
- The impact studies discussed in section 2d take 3 methodological approaches.
    - The simplest ones (e.g., Pucher and Renne 2003) use information on driving patterns and other variables in the absence of tolls to project the distributional impact of a proposed tolling project. The projections do not take behavioral adjustments to tolls into account.
    - A second set of studies (e.g., Sullivan 2002, Burris and Hannay 2004, Parkany 2005) uses data collected after a tolling project has been implemented to examine the economic status of users and non-users of the tolled facility. Some rely on descriptive statistics; others use multivariate models to inform

their conclusions. Like the first set, these do not take behavioral adjustments into account.

  - The most sophisticated studies (Small 1983, Safirova 2003, Franklin 2007) apply simulation models derived from multivariate statistical models to data for households in a specific location. The simulations adjust for some of the behavioral responses. They are able to examine changes in both financial costs and driving time to yield a more complete accounting of the toll's net economic impact on each household and then aggregate across households to determine the distributional impact.

- Most studies find that the financial costs of tolls are regressively distributed. The regressivity increases when time savings are taken into account because time is generally assumed to have a higher value for higher income persons. If, however, significant numbers of poor households also place a relatively high value on time, the regressivity would be less and, among poor users of a tolled facility, those with a high value of time will benefit more than will other poor users. Future research could fruitfully investigate the extent to which the value of time varies among the poor (and other income classes). If the variance is substantial, incorporating this information into impact estimates would improve our understanding of how tolls' impacts vary among poor households.
- A toll will be regressive under three circumstances: 1) the poor lose the most in absolute terms while other income groups either lose less or gain (Small 1983, Safirova 2005); 2) the costs to the poor are a higher percentage of their income, but not necessarily higher in absolute terms; or 3) the poor receive net benefits from the toll but the benefits are a smaller percentage of their income than benefits received by higher income groups (Safirova et al. 2003).[15]
- HOT lanes with adjacent untolled lanes are likely to have different equity impacts than full-facility tolling. HOT lanes are voluntary, so the toll can be readily avoided at the cost of longer travel time on the same route. Drivers cannot avoid a full-facility toll except by using a different route or mode. Thus, one should not base conclusions

15 Franklin (2007) reports that a toll on the SR 520 bridge is regressive but presents his findings in a way that prevents us from determining which of the three circumstances apply in this case.

about the equity impacts of full-facility tolling regimes on studies of HOT lanes, and vice versa.

- The use of toll revenue is a key determinant of whether poor persons, on net, gain or lose from a project. While it may be possible, in principle, to redistribute the revenue so that all income groups receive net benefits, there are substantial political and administrative obstacles to such redistributions, and none have yet been implemented. Washington and other states are most likely to fully devote revenues to the construction, improvement and maintenance of tolled facilities and, if funds suffice, other transportation projects.
- Using tolls to finance a project will generally impose fewer costs on the poor than using broad based consumption-oriented taxes such as the gas tax.

Section 3: Data Needs and Review of Existing Data (Objective 2)

We reviewed possible sources of data on individuals and households for their ability to provide helpful estimates of transportation patterns and toll effects in the Puget Sound. Data sets needed to contain large enough sample sizes to draw statistically reliable inferences about the general population. Differentiating poor from non-poor required a measure of income and household size. Information on the key transportation factors—car ownership, employment, and home and work locations—was also needed.

After a preliminary search, we identified and assessed the three most promising sources of data: the U.S. Census Bureau's 2007 American Community Survey (ACS), the Washington State Office of Financial Management's Washington Population Survey (WaPop) for 2004 and 2006, and the Puget Sound Regional Council's 2006 Household Activities Survey (HAS). We identified the ACS and HAS as most useful for different parts of the analysis. The American Community Survey includes the best information about income, employment, car ownership, and commute modes. We used it to create information about these factors for Section 4's analysis. The Household Activities Survey best allowed us to generate specific information about current travel routes of poor and non-poor households. We chose not use the WaPop because its sub-sample of each county's residents was not representative of the county population and its household information was no better than the ACS's. Appendix B provides additional details on the three datasets and their relative strengths and drawbacks. Section 5 also discusses suggested changes to the HAS and WaPop.

Section 4: Empirical Analysis and Preliminary Estimate of Tolls' Impacts on Poor Households (Objective 3)

The literature review identified factors needed to evaluate the impact of a tolling regime on low-income populations: a.) car ownership, b.) employment, c.) post-toll travel patterns, d.) economic impacts due to pricing and collection mechanisms and e). larger revenue considerations. Pricing and collection mechanisms and other revenue issues can only be evaluated in the context of a specific tolling plan. This is beyond the scope of the current investigation. Current car ownership, employment and current travel patterns are knowable, however.

This section presents new evidence about these factors. Using a unique geographic-specific routing analysis, we map current routes and make the assumption that these are the best possible estimate of post-toll travel patterns. We then draw on this evidence to derive a preliminary estimate of the impact of tolls on poor and non-poor households in the Puget Sound region. The section concludes with a discussion of the substantial limitations of the empirical analysis.

Descriptive information about population poverty, employment, and car ownership comes from the 2007 ACS Public Use Microdata Sample Files for King, Pierce, Snohomish, and Kitsap County. This data set includes 34,106 individuals in 14,911 households, and can be weighted to represent the population at large.

The analysis of travel patterns is based on the 2006 HAS, which included households in the same four-county area as the ACS. The HAS contains exact longitude and latitude coordinates for home and work information for 4,685 individual respondents. These coordinates were mapped using Geographical Information Systems (GIS) software, and an algorithm was created to determine the most likely commute route for each pair. A series of technical appendices with greater detail on the data sources, mapping and analysis procedures follow the main report.

Our analysis improves on past research in two major ways. Prior studies generally examine only drivers who use tolled facilities and, sometimes, drivers who do not use tolled facilities. By omitting the many poor households without workers, or with commuters who do not use private vehicles, such studies overstate the effect of tolls on the entire poverty population. We examine tolls' impact on all poor households in the region as well as sub-groups of poor households with workers who drive on tolled and non-tolled facilities. We find important differences among sub-groups in the cost of tolls.

Second, to our knowledge, this research study is the first to use GIS methods to map driving routes from home to work. We can then determine the extent to which poor households commute on highway segments that may be tolled in the future and compare how frequently poor and non-poor households commute on each segment.

The estimates assume that tolls do not affect current commuting patterns. We make this assumption in view of data limitations and the scope of the study. Because generally accepted models of travel behavior imply that tolls induce some drivers to change modes, routes or other relevant behaviors, tolls' financial costs for both poor and non-poor households will be lower than reported in this study. The last part of this section further discusses the study's limitations.

Poverty Measure

In this analysis the federal definition of poverty delimits poor from non-poor. This poverty measure uses a set of dollar value thresholds that vary by family size and composition. If a family's income is below the appropriate threshold, all members of the family are considered to be in poverty. The thresholds do not vary geographically. The U.S. Census Bureau annually updates the thresholds for inflation using the Consumer Price Index for All Urban Consumers (CPI-U).

The official definition measures income as money received from wages, self-employment income, dividends, interest, rental income, child support, and government cash benefits such as Social Security, Supplemental Security Income, unemployment insurance and public assistance. In 2009, the official threshold for a family of 3 was $18,310. For 4, it was $22,050.

Critics argue that the federal poverty measure is too low, particularly in high-cost areas such as the Puget Sound (Pearce & Brooks, 2001). Attempts to re-write the federal measure have been unsuccessful to date, and it remains the standard for nearly all federal programs (Blank, 2008; Citro & Michael, 1995).

To address the concern that the poverty line inadequately distinguishes the economically disadvantaged, in some analyses we include a second category of "near-poor." Near-poor families have incomes above the poverty line but below twice that amount. Using the 2009 threshold, a family of 4 would be near-poor with income above $22,050 but below $44,100.

Looking at the near-poor is conceptually warranted because near-poor households share many characteristics with poor households that contain workers. Research on changes in household income over time shows that many households that are poor in one year may become near-poor the next year and vice versa as family income fluctuates (Cellini, McKernan, & Ratcliffe, 2008). Because households with workers are those that commute, looking at both poor and near-poor may more fully inform us about poor workers. Results for the near-poor appear in Appendix D.

Poor and Non-poor Populations in the Puget Sound Region

In 2007, 7.7 percent of all households in King, Snohomish, Pierce, and Kitsap Counties fell below the poverty line. The national poverty rate was 12.5 percent (DeNavas-Walt, Proctor, & Smith, 2008). The region's lower rate of poverty likely reflects the Puget Sound's higher wage rates and better-than-average economic conditions at that time.

Figure 1 shows the concentration of poor households across the region. Darker colors indicate higher percentages of poor households. Poverty is more concentrated in southwestern King County and northwestern Pierce County. Eastern and northern King County have lower concentrations of poverty. In terms of highway access, the poorest areas are located adjacent to I-5 and SR 167.

Employment, Car Ownership, and Commute Mode

Because commuting to and from work is the major non-discretionary transportation activity, employment and commute patterns are key in understanding potential impacts of tolls. Persons drive for other reasons, but generally have more time flexibility in scheduling and getting to and from non-work activities.

Table 1 shows information on employment and commuting among Puget Sound households below and above the poverty line. Over three quarters of poor households and nine out of 10 non-poor households contain at least one worker. More than two thirds of poor households and 95 percent of non-poor households own at least one car. On average, a poor household owns one car and a non-poor household owns two.

Workers who currently commute via single occupancy vehicles are likely to be most affected by any new tolling regime. The bottom panel of Table 1 shows commute mode. Driving to work alone is most common, with 60.9 percent of poor individuals and 75 percent of non-poor individuals commuting in this way. Poor workers are slightly less likely to carpool than non-poor workers (8.1 percent vs. 8.6 percent), but more likely to use public transportation (18.5 percent vs. 7.2 percent) or other modes such as walking or biking (12.4 percent vs. 9.4 percent). On average, the poor and non-poor both spend slightly more than 28 minutes commuting.

Table 1 confirms what other research has demonstrated: the poor in the Puget Sound Region are much less likely than their near-poor or non-poor counterparts to use a personal vehicle to get to work, although considerably more than half still manage to do so. They are more likely than the near-poor or the non-poor to commute using public transportation or other modes that would not be subject to tolls. These facts imply that that a smaller percentage of the poor than the non-poor are likely to be affected by tolling in the Puget Sound region.

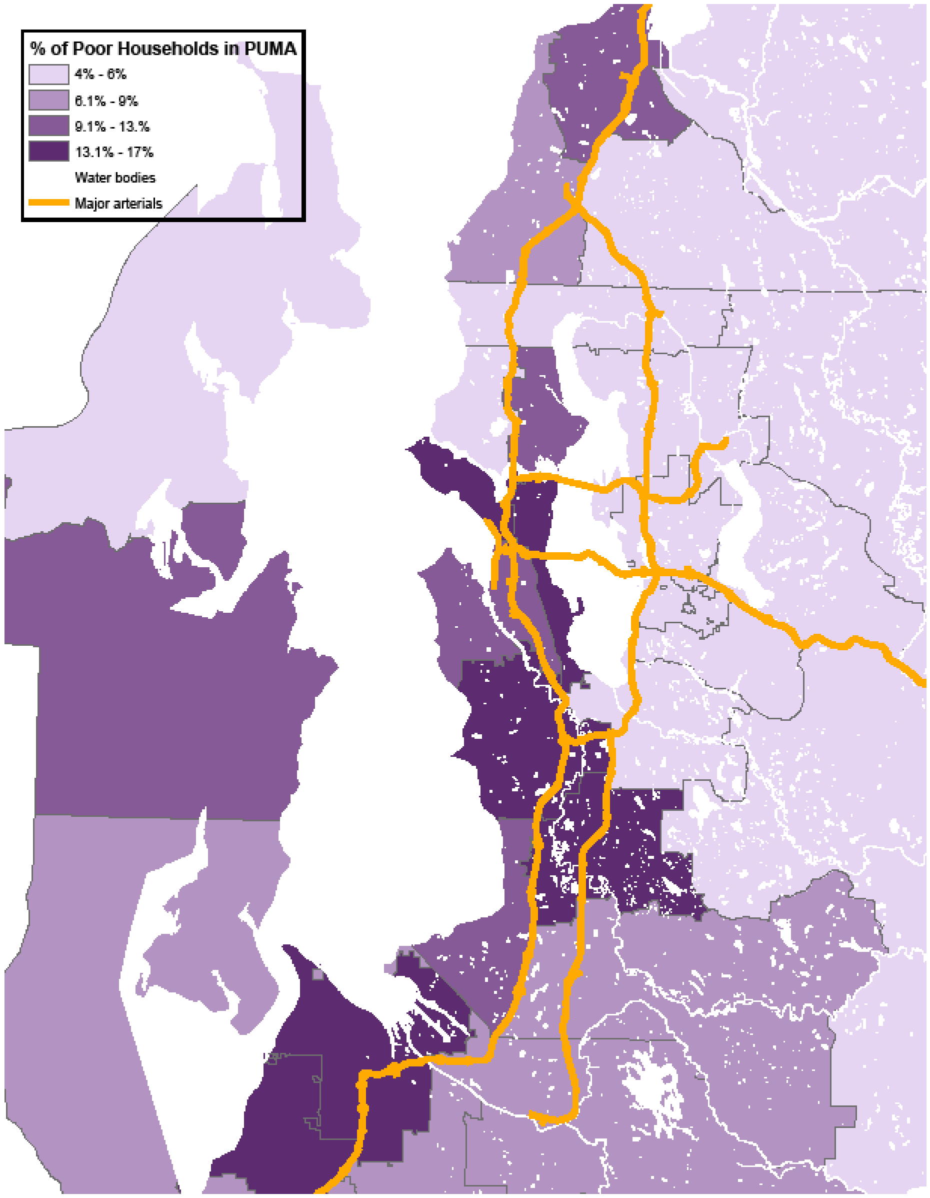


Figure 1. Poverty Rates for Puget Sound Public Use Micro Areas (PUMAs) in 2007

(Authors' calculations using 2007 American Community Survey data, N=34,106 individuals in 14,911 households)

Table 1. Employment and Commute Information by Poverty Category

(Authors' calculations using American Community Survey data, N=34,106 individuals in 14,911 households, weighted to represent Puget Sound Area)

	Poor Households (100% FLP or below)	**Non-poor Households (More than 100% of FPL)**
Population (%)	7.7%	92.3%
Characteristics of all households		
Contain one or more workers*	77.3%	90.5%
Mean number of workers*	0.99	1.64
Car ownership (%)*	69.3%	94.8%
Mean number of cars*	1.01	1.95
Commute characteristics of workers (individual level)		
Mode		
Drives alone*	60.9%	75.0%
Carpools*	8.1%	8.6%
Public transportation*	18.5%	7.2%
Other commute mode*	12.4%	9.4%
Commute time in minutes*	28.2	28.6

*Significant at a 95% confidence interval

Mapping Commuting Routes of the Poor and Non-poor

The HAS contains both basic demographic information and detailed latitude and longitude locations for home and work. We merged the demographic and latitude-longitude information and created a GIS (Geographic Information Systems) database. [16] We created and applied a mapping algorithm to assign the most likely route between each home and work pair. We manually checked assigned routes against Google Maps to

[16] This analysis was designed and performed gratis by Matt Dunbar of the University of Washington's Center for Studies in Demography and Ecology.

identify implausible routes, and made hand edits as needed. Appendix C provides details about the data and mapping algorithms.

This route information captures the distribution of commuting trips on both major and minor roads. Figure 2 shows the trip density for all commuters in Puget Sound. Thicker lines indicate greater numbers of commuters on a given route. Not surprisingly, commuters use the section of I-5 adjacent to downtown Seattle most heavily.

To assess the impact of different toll scenarios, we divided the major highway system into 12 focal segments, each a different part of I-5, I-405, I-90, SR 520, SR 167, or SR 99 in King County. We chose segments for which tolls have already been discussed or implemented, or that appear to be plausible candidates for congestion tolls. For example, the SR 520 bridge is one segment. The stretch of I-5 from its junction with I-405 on the north and SR 520 on the south is another. Table 2 describes the segments. The GIS route information enables us to estimate the distribution of use of highway segments by both poor and non-poor commuters.

Figure 3 shows how many focal segments were used by poor and non-poor commuters. The modal poor commuter's route does not include any segments. Twenty percent of poor commuters use one or two segments; only 17 percent use three or more. In contrast, 30 percent of non-poor commuters' routes include one or two segments while a quarter of them use three or more.

Which segments are most popular among the poor and non-poor? Table 2 displays rates of poverty among segment users and the frequency of segment use by poor and non-poor commuters. First we examine the proportion of each segment's users that is poor. The section of I-405 south of I-90 (stretching from south Bellevue through Renton) has the highest share of daily commuters below the poverty line—6.2 percent. The section of I-405 between I-90 and SR 520 has the second highest rate of poverty among users—5.4 percent. SR 167 is third with a poverty rate of 5.1 percent. The downtown segment of Highway 99 has the lowest portion of poor, estimated to be zero in this sample.

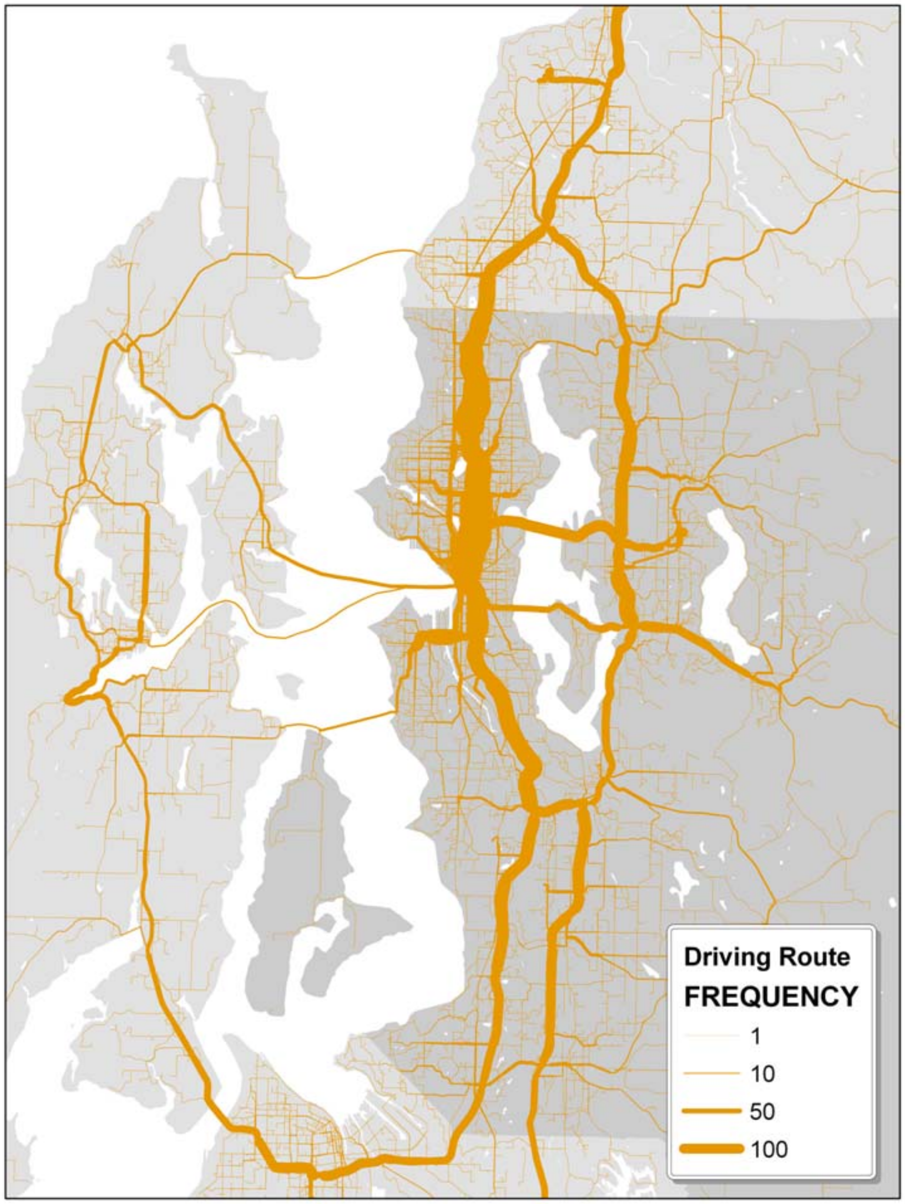
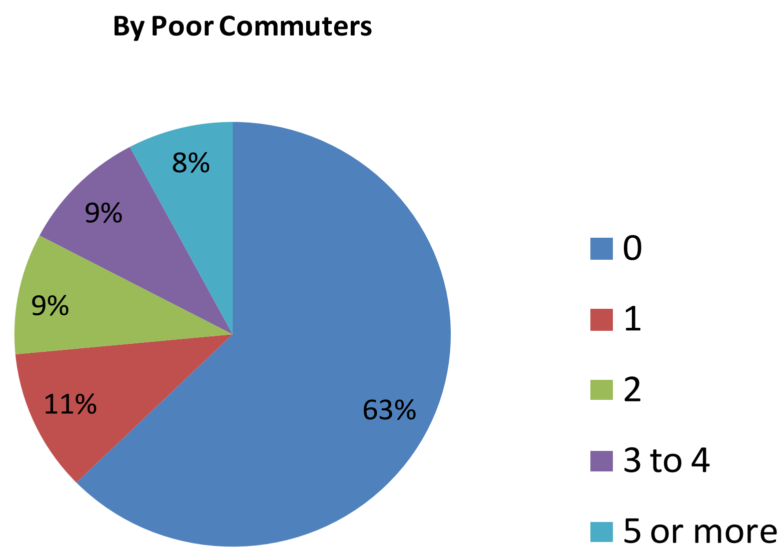


Figure 2. Route Density, All Commuters

Authors’ calculations using the Household Activities Survey



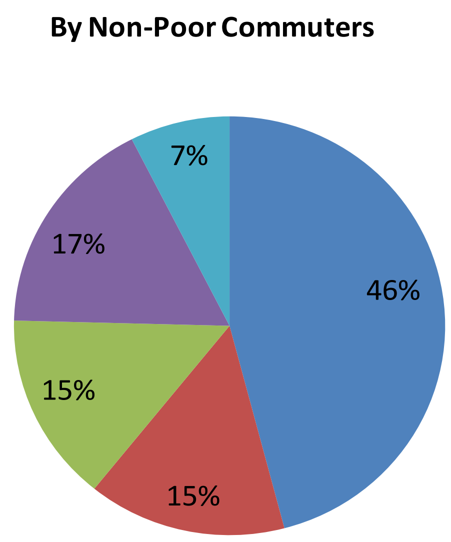


Figure 3. Number of Focal Highway Segments Used

Authors’ calculations using the Household Activities Survey.

Table 2. Use of Focal Highway Segments by Poor and Non-Poor Commuters

(Authors' calculations using weighted Household Activity Survey data and GIS routing procedure. See text and appendix for details.)

Highway segment	**Poverty rate among segment users**	**Use of segment**			
		Among poor commuters		**Among non-poor commuters**	
		All, N = 53,894	**Segment drivers,* N = 18,243**	**All, N = 1,317,202**	**Segment drivers,* N = 588,647**
1 – I-5 north from SR 520 to I-405	1.8%	6.2%	18.2%	13.9%	31.2%
2 – I-405 north from SR 520 to I-5	4.2%	9.2%	27.3%	8.7%	19.4%
3 – SR 520 bridge	2.8%	2.9%	8.6%	4.1%	9.2%
4 – I-5 between SR 520 and I-90	3.2%	12.1%	35.0%	15.0%	33.6%
5 – I-405 between SR 520 and I-90	5.4%	11.2%	33.2%	8.1%	18%
6 – I-90 bridge	2.8%	2.6%	7.6%	3.7%	8.2%
7 – I-5 south from I-90 to I-405	1.9%	4.6%	13.5%	9.6%	21.5%
8 – I-405 south from I-90 to I-5	6.2%	14.3%	42.1%	8.8%	19.7%
9 – I-5 south from I-405 to King County line	3.7%	5.7%	16.8%	6.0%	13.5%
10 –SR 167 south of I-405 junction	5.1%	10.1	29.7%	7.7%	17.2%
11 – SR 99 from W. Seattle Bridge to tunnel	0.0%	0.0%	0.0%	1.3%	2.9%
12 – I-90 east of I-405	2.4%	2.6%	7.6%	4.3%	9.7%

*Highway drivers are those who use at least one of the indicated segments.

Next we look at the routes most commonly used by poor and non-poor commuters. We look at all commuters, including non-drivers and surface street users (columns 3 and 5), and then at drivers who use at least one of the focal highway segments (columns 4 and 6). Not surprisingly, the same segment of I-405 from south Bellevue to Renton is the most commonly used among poor commuters (row 8). Fourteen percent of all poor commuters and 42 percent of poor highway users have this segment in their commuting route. The second and third most commonly used segments are I-5 adjoining downtown Seattle (between SR 520 and I-90), and I-405 between SR 520 and I-90 (rows 4 and 5). Among non-poor drivers, the most-used segments are I-5 adjoining downtown Seattle and (row 4) the section of I-5 north of SR 520 to the I-405 junction (row 1).

Preliminary Impact Estimates

In this section we derive preliminary estimates of poor households' cost of tolls and compare it to the cost borne by non-poor households. To do so, we examine two illustrative families. One is a family of three with an income of $17,600, which exactly equals its 2008 official poverty line. The second family has an income of $68,800, which is the projected median income of King County households in 2008 (see http://www.ofm.wa.gov/economy/hhinc/medinc.pdf).[17] We do not provide estimates across the observed distribution of poor and non-poor households because of the limitations of HAS income data.

Scenario 1 assumes that a $2 one-way toll is imposed on all 12 focal segments listed in Table 2. We estimate the annual cost of tolls under this regime for three nested groups of families. The largest group is all households, regardless of whether anyone in a household works, drives a private vehicle to work or uses a tolled segment. The average poor household in this group drives on 0.80 tolled segments per day. The average non-poor household drives on 1.32 segments per day.

The second group includes only all households with at least one person who commutes in a private vehicle, regardless of whether he uses a tolled segment. The average number of tolled segments used per day by poor and non-poor households is 1.04 and 1.46. Note that many households in the first and second groups would pay no tolls.

The third group is further restricted to households with at least one person who drives a private vehicle on at least one tolled segment. All of these households pay tolls. Among these households, use is roughly independent of income. The average number of segments driven per day for poor and non-poor households is 2.79 and 2.69.

[17] Since a projection of 2009 median income is unavailable, examining a family at the 2008 poverty line provides a better comparison.

Scenario 2 assumes a $2 one-way toll only on the SR 520 bridge. We estimate the annual cost of this regime for the three groups in scenario 1 and for the much smaller group of households that actually use the bridge.

For both scenarios we compute the annual cost assuming 240 work days per year. A commuter who drives roundtrip on one segment would pay $2 x 2 (roundtrip) x 240 = $960 per segment per year.

Table 3 presents the results. Comparing toll costs for poor versus non-poor households suggests that the poor will pay a higher proportion of their annual income than the non-poor at every level of analysis. Consistent with prior research, we find that the financial impact of both tolling regimes is regressive.

Under scenario 1, the average poor household pays $772 per year, or about $500 less than what a median income household would pay. As a percentage of income the poor pay much more—4.4 percent compared to 1.8 percent. Among commuting households, the cost is necessarily higher—$999 for the poor and $1,399 for the non-poor. Again in absolute terms the poor pay less, but in relative terms their burden is much higher—5.7 percent of income versus 2.0 percent. For just those households with commuters who actually drive on tolled segments, the average yearly cost is much higher—about $2,600 per year for both poor and non-poor households. This cost would absorb more than 15 percent of the poor household's income, a rate four times higher than that for a median income family.

Devoting 15 percent of income to tolls would force large reductions in other types of expenditures and, hence, substantially reduce the economic well-being of poor households whose workers commute in private vehicles. In the absence of specific efforts to subsidize tolls for low-income households, tolls would probably induce many of them to adopt less costly commuting arrangements.

The burden of tolling all segments would be highly unequal among both poor and non-poor households in the Puget Sound region. Poor and non-poor users of tolled segments would pay an average of $2,675 and $2,586 per year. Non-users, of course, would pay nothing.

Table 3. Hypothetical Annual Toll Burdens for Poor and Non-poor Households

	Poor household (Income=$17,600)		Non-poor household (Income=$68,800)	
	Cost of tolls	Percent of income	Cost of tolls	Percent of income
Average annual cost under full-system tolling of $2/segment, for:				
All households	$772	4.4%	$1,266	1.8%
Commuting households	$999	5.7%	$1,399	2.0%
Segment commuters	$2,675	15.2%	$2,586	3.8%
Average annual cost under SR 520 bridge toll of $2, for:				
All households	$25	0.1%	$54	0.1%
Commuting households	$33	0.2%	$60	0.1%
Segment commuters	$87	0.5%	$111	0.2%
Only SR 520 bridge commuters	$960	5.5%	$960	1.4%

The lower part of Table 3 presents findings for scenario 2, in which only the SR 520 bridge is tolled. The $2 one-way toll would cost the small number of poor households that use the bridge $960 per year, or 5.5 percent of income. The corresponding small set of non-poor households would also pay $960, or 1.4 percent of their income. Spending about $1,000 on tolls would certainly reduce the economic well-being of poor users of the SR 520 bridge and encourage them to seek less costly commuting arrangements. The adverse impact on well-being and the likelihood of changing travel routes would, naturally, be smaller than in scenario 1.

Limitations of the Empirical Analysis

While our study improves on prior work in some significant ways, it also has several important limitations. These limitations call for caution in interpreting the findings and drawing policy conclusions from them.

First, because the sample of poor households in the HAS is small, the estimates based on this data set in Table 2 are imprecise. Consequently, the projections of annual toll costs in Table 3 are also imprecise.

The study does not estimate how potential tolls would affect driving times on tolled segments and other roads and by buses and carpools and how these effects would differ for poor and non-poor households. Information on changes in commuting time and its value to both poor and non-poor households is needed to obtain a more complete picture of the equity effects of tolls.

The projections in Table 3 assume tolls do not vary by time of day. The level and distribution of the costs of congestion tolls may differ. The projections also assume that drivers of a tolled segment have no option other than paying the toll. HOT lanes with adjacent untolled lanes are an alternative method of tolling. Drivers who never use HOT lanes would pay no tolls and drivers who do not always use a HOT lane would pay less compared to levying tolls on all drivers using a stretch of highway. This approach would lower the burden of tolls on poor households. It would almost surely result in a different distribution of tolls' benefits and costs between poor and non-poor households, and among poor households, compared to a constant toll that all users must pay.

Finally, the estimates are based on current commuting patterns. They do not take into account that some drivers may change routes, modes, and other relevant behaviors in response to the tolls and the associated costs of accessing tolled highways (need for credit card or bank account, deposits, service fees). To the extent that such changes occur, the financial costs for both poor and non-poor households will be lower than reported in this study.

Section 5: Methodological Suggestions (Objective 4)

The analysis used already collected data to estimate possible impacts of tolling on low-income populations in the Puget Sound area. Relying on extant data sources allowed for an immediate estimate, but also revealed considerable weaknesses in the ability to accurately estimate current use. Additionally, the state of knowledge about household responses to tolls is not robust enough to allow us to determine how current use patterns would be likely to change in reaction to a tolling regime in the Puget Sound region.

We offer two suggestions for future research that could yield better information on tolls' impact on low-income populations in Puget Sound. The first is to collect more or slightly different information from existing ongoing surveys. Doing so would provide better data with which to conduct the type of analysis in section 4. The second suggestion is to conduct a randomized field experiment that identifies regional travel patterns and how they are likely to change in response to tolls. This would be a major undertaking with the potential to significantly advance knowledge about responses to tolling regimes more generally

Any additional research effort requires investment of funds and effort on the part of the state and any study participants. The value of results must always be weighed against such costs.

1. Augment Existing Data Collection

This project identified several limitations of extant data. We reviewed three data sets—WaPop, PSRC-HAS and the U.S. Census Bureau's American Community Survey. All three have weaknesses that could be addressed by adding additional items or collecting data differently. Since WSDOT would most likely be able to partner with a state or local agency that collects demographic and economic data, we have suggestions for improving the WaPop and HAS.

The WaPop or the HAS could add items that provide better information on possible impacts of tolling or other transportation decisions on vulnerable populations. The WaPop collects detailed data on income and household composition, but not on work location. Home location is collected at some point in the surveying process, but this information is generally not available to WaPop's users. We specifically requested this data but were denied on grounds of confidentiality. Collecting geographically specific information on workplace and making available such information on home location would allow WaPop to be used for a route analysis like the one done with HAS in this report. Three important advantages of using WaPop are that it has a larger sample than the HAS, has better income information and, unlike the HAS, is repeated biannually.

The HAS's detailed information on location made it suitable for the route analysis. But it categorized household incomes into $10,000 ranges ($0-9,999, $10-19,999, etc.) For many households this crude measure made it difficult to determine their poverty status.[18] Asking for exact income amounts or narrower ranges would be helpful for our purposes. Advantages resulting from a change in income measurement must be weighed against the increased burden on respondents.

Both the WaPop and HAS have relatively small sample sizes of the poor because this group constitutes a small percentage of the population and it tends to be disproportionately harder to reach in survey work. Concerted efforts to oversample low-income households would increase the precision of the findings and allow better comparisons of tolls' impacts across important sub-groups of the poor (e.g., single and two parent families; minorities and those with limited English proficiency).

2. Conduct a Randomized Trial

A second option is to conduct a randomized policy experiment in advance of or, preferably, during the implementation of a new tolling regime. This would both add to local practical knowledge about the impact of tolling on different population segments and contribute to the generalizable professional and scholarly knowledge base about how transportation behaviors respond to incentives and costs.

Similar to a randomized drug trial conducted in medical research, such an experiment would randomly assign some drivers or households to different levels of tolling and then track their responses. For instance, households could be recruited into the study, given a transponder, and then randomly assigned to pay no toll, a $2 toll or a

[18] Suppose a family of three reported income in the $10-19,999 range. Since the three-person poverty line is $17,600, it is unclear whether this family is poor.

$4 toll on a given route, such as westbound trips on the SR 520 bridge. This is similar to the Traffic Choices study conducted by PSRC, but with the addition of randomization.

Social policy experiments are widely recognized as a preferred design for policy research. They provide better estimates than do designs based on statistical analysis of non-experimental data (Rutter, Pickles, Murray, & Eaves, 2001; Heckman, LaLonde, & Smith, 1999; LaLonde, 1986). Results from studies with treatment and control groups are also easy to explain to policymakers and the general public (Burtless, 1995; Greenberg, Linksz, & Mandell, 2003). To our knowledge this research design has not been used in transportation research (Mark Hallenbeck, conversation, February 17, 2009).

Like the Traffic Choices study, a randomized trial could be done as a stand-alone experiment in advance of an actual real-world toll implementation. There are, however, substantial advantages to tracking behavioral changes in conjunction with a real-world roll-out. Any simulation is necessarily limited in its ability to capture the full, "general equilibrium" effects of a large policy change. For instance, a new toll gets considerable public attention through the media and via conversations in social networks. The "buzz" that accompanies a new toll helps inform commuters of their choices and is impossible to replicate in a small study conducted before a toll is imposed, in which participants do not necessarily know each other and there would be no buzz.

Section 6: Summary and Conclusion

To improve our understanding of how tolling is likely to affect low-income populations in the Puget Sound region, this report accomplishes four objectives. It:

1. reviews existing research on the impact of tolling on low-income households in the United States.
2. assesses the usefulness of currently available Washington and Puget Sound data for estimating the impact of tolling on low-income populations.
3. develops a preliminary estimate of the impact of tolling on low-income populations living in the Puget Sound region.
4. suggests data collection and methodological strategies for future research that would yield better estimates of the impact of tolling on low-income populations in the Puget Sound region and other parts of Washington.

This section summarizes findings for each objective and offers some concluding observations.

Objective 1. Existing Research

There is limited research on the main factors that determine tolls' equity impacts. These factors are car ownership, employment, behavioral responses to tolls, and post-toll use of roads and bridges. Key findings from prior studies we reviewed are:

- Equity impacts are always project and region specific.
- Poor households differ in car ownership, employment, commuting needs and use of non-car modes of travel. Thus, tolls' impacts differ among poor households. The literature does not examine such differences empirically.
- The financial costs of tolls are regressively distributed. The regressivity increases when time savings are taken into account
- Use of toll revenue is a key determinant of whether poor persons, on net, gain or lose from a tolling regime.
- Using tolls to finance a project will generally impose fewer costs on the poor than using broad based consumption-oriented taxes such as the gas tax.

- To have a full picture of the equity effects of tolling, one must compare those effects to the effects of an alternate financing method in a no-toll scenario.

Since prior studies use an income higher than the official poverty line to identify poor households, their findings may not fully apply to officially poor households.

Objective 2. Usefulness of Current Data

We assessed the 2007 American Community Survey (ACS), the Washington Population Survey (WaPop) for 2004 and 2006, and the Puget Sound Regional Council's 2006 Household Activities Survey (HAS). The ACS provides the best information about income, employment, car ownership, and commute modes. The HAS is valuable because it allows us to generate specific information about current travel routes of poor and non-poor households. The WaPop is much less useful because its sample of each county's residents is not representative of the county population.

Objective 3. Estimate of Tolling Impacts

We conducted original empirical analyses of commute patterns in the Puget Sound region and used the results to project impacts of hypothetical tolling regimes. The poor in the Puget Sound region are much less likely than the non-poor to commute in a personal vehicle, and more likely to commute using public transportation or other modes that would not be subject to tolls. Thus, a smaller percentage of the poor than the non-poor are likely to be affected by tolling in the Puget Sound region.

Our study estimates the financial impact of two tolling regimes. The first imposes a one-way toll of $2 on 12 major road segments in King County for which tolls have already been discussed or implemented, or that appear to be plausible candidates for congestion tolls. The average annual cost for a poor household would be $772 or 4.4 percent of income. Similarly, for the average non-poor household the cost would be $1,266 or 1.8 percent of income. These averages are taken across all poor and non-poor household, whether or not they commute on tolled segments.

If we restrict attention to only households that drive on one or more segments, the average cost is much higher—about $2,600 per year for both poor and non-poor households. Such tolls would absorb 15.2 percent of a poor household's income, or about four times the rate for a non-poor household. Devoting 15 percent of income to tolls would force large reductions in other types of expenditures and, hence, substantially reduce the economic well-being of poor households whose workers commute in private vehicles.

The burden of full system tolling would be highly unequal among both poor and non-poor households. Poor and non-poor users of tolled segments would pay about $2,600 per year. Non-users, of course, would pay nothing.

The second regime imposes a $2 one-way toll only on the SR 520 bridge. The small number of poor households that use the bridge would pay $960 per year, or 5.5 percent of income. The corresponding small set of non-poor households would also pay $960, which would equal 1.4 percent of their income. Spending about $1,000 on tolls would certainly reduce the economic well-being of poor users of the SR 520 bridge.

Our study has several important limitations: 1) Estimates based on the HAS are imprecise because its sample of poor households is small. 2) We could not estimate tolls' effects on driving times on both tolled segments and other roads and by buses and carpools and how these effects would differ for poor and non-poor households. 3) Our projections assume tolls do not vary by time of day. The level and distribution of the costs of congestion tolls may differ. 4) Our projections assume that drivers on a tolled segment have no option other than paying the toll. HOT lanes with adjacent free lanes are an alternative method of charging tolls. With a HOT lane approach, the benefits and costs of tolls for poor and non-poor households would almost surely differ from the time- and congestion- invariant approach hypothesized in our projections. So, too, would the distribution of the benefits and costs among poor households and between poor and non-poor households. 5) Our estimates are based on current commuting patterns and do not take into account tolls' effects on travel mode, route, or other relevant behaviors.

These limitations call for caution in interpreting the findings and drawing policy conclusions from them.

Objective 4. Future Research

Future research needs to collect more or slightly different information from existing ongoing surveys, to better estimate tolls' impacts on low-income populations in

Puget Sound. Emphasis should be placed on oversampling poor households and obtaining high quality data on income and home and work locations.

In addition, conducting a randomized field experiment could better identify how regional travel patterns are likely to change in response to tolls. Such an experiment would be a major undertaking with the potential to significantly advance knowledge about responses to tolling regimes.

Conclusions

The overall purpose of this report is to further understanding of how tolling is likely to affect low-income populations in the Puget Sound. We believe that the work summarized above provides the best possible estimate given the resource and data constraints. Because effects of tolling are region-specific, we needed to and did create new information about tolling patterns in the Puget Sound. We calculated distributional effects of tolling using two hypothetical tolling regimes. The detailed route analysis presented in Section 4 allows for additional scenarios to be approximated post-hoc.

We find that most poor households would not be substantially affected by tolling. However, those who use routes to be tolled and do not have ready alternatives will have their economic well-being decreased. For the small number of poor households without alternatives, the financial effect of tolling could be large. One hypothetical simulation suggests that a poor household could pay up to 15 percent of its income on tolls.

The question of whether tolls disproportionately affect the poor relative to the non-poor requires a both a definition of equity and a full policy proposal that specifies how tolls will be collected and how tolling fits into larger public revenue flows. One equity concern is whether relative effects on different groups differ. Our simulation shows that the average poor household will pay a greater percentage of its annual income on tolls than will the average non-poor household. That is, the poor will pay a relatively larger share of their income than the non-poor. Whether relative budget burden is the correct definition of equity and whether the disproportionate burden could be offset by other revenue considerations are larger political questions beyond the scope of this report.

Section 7: Implementation of Research

This research will assist WSDOT in the development of environmental documents as part of NEPA.

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Appendix A: Summary of Analyses of the Use of Toll Revenues

Researchers have proposed several ways that the revenues could mitigate any direct, negative financial effects on poor users of tolled facilities. Giuliano (1994) suggests that "the magnitude of toll revenues would make it possible to offset existing regressive taxes and thus improve the equity of transportation funding." Similarly, Gomez-Ibanez (1992) observes that congestion tolls set at short run marginal costs would generate enormous revenues that could far exceed the amount needed for facility improvement or expansion. He suggests finding a "politically attractive use for toll road profits," such as general tax relief.

Small (1983) extends his findings cited above by analyzing the distributional impact of the revenues generated by a hypothetical peak expressway toll. He considers three scenarios – when revenues are redistributed proportionately to users according to income, redistributed on an equal, per-capita basis, and redistributed in a pro-poor manner. Under all three, every income group ended up being better off. In the proportional and equal, per capita scenarios, the lowest income groups benefited less than the higher income groups because the latter placed higher value on the time savings as a result of the toll. Franklin's (2007) analysis of a toll on WA SR 520 similarly finds that the benefits from a lump-sum repayment can counteract the regressivity of the toll's other components.

Importantly, Small (1983) also finds that it was **not** possible to make all low-income individuals better off. Those who were constrained to stay in their cars and were unable to change their time of travel, for whatever reason, and pay the toll were considerably worse off under the tolling regime. This result highlights the importance of assessing the distribution of tolling impacts <u>among poor households</u> along with the average impact on poor households and the distribution <u>between income groups</u>. Gomez-Ibanez (1992) echoes this point. He also cautions that while the gains of the winners might exceed the losses of the losers, designing a system in which groups of winners compensate groups of losers could be difficult.

Small's findings imply that it will be very difficult to satisfy Richardson and Bae's (1996) concern that "Redistribution of resources (including time and money) within the low-income group as a whole is not an acceptable substitute for compensating the specific drivers who are forced either to pay substantial sums in congestion fees or incur additional time costs resulting from diverted trips." That is, designing a "horizontally equitable" system of tolls and redistribution that fairly treats all low-income households may be impossible.

Small's second study (Small 1992) shows that the revenues collected from a potential area-wide congestion pricing project in the Los Angeles area could be very large. Indeed "the revenues are so large that there should be some money left over to promote social goals and to garner political support." He suggests using revenues to offset commute costs for employees, lower gasoline taxes and property taxes, and to fund new highways, public transportation and services to employment centers. The combination of time savings plus the offsets would nearly compensate low-income users and more than compensates wealthier users.

Other analysts also suggest using toll revenue to finance transportation improvements that would benefit poor people and increase the quality and quantity of low-cost transportation options (Prozzi et al. 2007, Weinstein and Sciara 2004). Additional options include using the revenue to support affordable housing options near employment sites and giving toll credits or exemptions to low-income drivers who must drive solo but cannot afford the toll, and (Prozzi et al 2007, Weinstein and Sciara 2004). Richardson and Bae (1996) similarly suggest cross-subsidizing congestion fees using electronic transponders to charge different rates to drivers in different income groups. None of these has yet been tried in the U.S. and no studies have projected their distributional effects.[1]

Some analysts express concerns about the amount of revenues that would become available and the willingness to spend them to benefit the poor. Franklin (2007) and Richardson and Bae (1996) warn that using revenues to address equity issues by redistributing them among facility users or to pay for transit improvements is unlikely as they would be needed to finance facility improvements. Safirova et al.'s (2003) study of

1 We observe that effective implementation of transponders that charge lower rates may be daunting. There may be resistance to the disclosure and possible misuse of personal financial data Also, a large black market for such transponders is likely to emerge. This will erode the intended redistribution of the tolling burden, create wide (and correct) perceptions of abuse and unfairness, and reduce toll revenues.

the effects of converting several HOV lanes to HOT lanes in northern Virginia argues that though revenue from the HOT lanes could be used to mitigate the disproportionate accrual of benefits to the wealthy, such revenue is too little to equalize benefits across income classes. Similarity, Weinstein and Sciara (2004) point out that though revenues have helped effectively resolve concerns about equity in a number of HOT lane projects, revenues beyond what are needed to fund the HOT lanes themselves cannot be counted on.

Appendix B: Dataset Comparison

One of the principal tasks that our research team was asked to perform in this study was to assess the usefulness of currently available Washington and Puget Sound data for estimating the impact of tolling on low-income and minority populations. After extensive searching, we identified three data sources that we felt had the potential to contribute to our understanding of the impact of tolling on low-income and minority populations. These were the Washington Population Survey, the American Community Survey's 2007 Public Use Microdata Sample for Washington State, and the Puget Sound Regional Council's 2006 Household Activity Survey. In this Appendix we will describe each dataset and assess its usefulness in estimating the effect of tolling on King County's poor populations.

Washington Population Survey (2004 and 2006)

Dataset and sample description – The Washington Population Survey, conducted every two years by the State's Office of Financial Management, has been instrumental in providing state and local policy makers with information on the physical, social, and economic health and welfare of Washington residents since it was first administered in 1998. Because the geographic region we were interested in for the purposes of this study was limited to King County, we limited our sample to households located in King County. In order to increase our sample size we combined the 2004 and 2006 datasets. When we began work on this study, the 2008 survey results were not yet available.

The combined dataset gave us a sample of 8,673 individuals living in King County, some of which were members of the same household. Of that, only 490 were "poor" (100 percent of Federal Poverty Level or below), and only 1,370 were "low-income." (200 percent of FPL or below).

Strengths – The Washington Population Survey (WaPop) has the advantage of being widely used and recognized throughout state government. It is familiar to policy makers at all levels, and it is easily accessible, both in terms of retrieving the data, and in interpreting the results.

For the purposes of our study, the WaPop was attractive because it provides very fine grained information on family size, and household income—in other words, it is easy to determine who in the sample fit our definitions of "poor" and "low-income," or "near-poor." Respondents also answered questions about their employment status, their chosen commuting modes, and the amount of time it usually took them to get to work, all of which are potentially valuable pieces of information in a study to determine the potential impact of tolling on poor people.

***Weaknesses* –** Unfortunately, the WaPop could not give us any sort of detail about *where* in King County the poor people we were interested in either lived or worked, or whether or not they were likely to even use a potentially tolled route. In order to get finer geographic resolution, we requested zip code information for each of the participating households, but were told that privacy concerns prevented the release of that data. Instead, we were given aggregated zip code information for five regions in King County. This allowed us to have a better idea of where poor, near-poor and non-poor people within the sample lived, but we were warned that the results may not be representative of the larger population because the sampling was not based on those geographic divisions.

***Conclusion* –** The WaPop is a good source of information for finding out employment status of different income groups in King County, how different income groups commute, and how long it takes them to get to work on average, but its inability to provide representative data about where the poor, near-poor, and non-poor are likely to live and work limit its usefulness for this study.

American Community Survey (2007)

Dataset and Sample Description - The ACS, an ongoing survey conducted by the U.S. Census Bureau, replaces the U.S. Census Long Form. Each month, one in 480 households in every county in the country is asked to participate. The one year Public Use Microdata Sample Files contain about one percent of the total nationwide records. In this case we used 2007 PUMS data for Washington State's Puget Sound Region—King Pierce, Snohomish and Kitsap counties (34,106 individuals). The King county sample is

16,860 individuals. Of those, 1189 individuals are poor (100 percent of FPL or below) and 2768 individuals are low-income (200 percent of FPL or below).

Strengths – Like the WaPop, the ACS is widely recognized as a reliable source of data and is used by policy makers in a wide variety of decision making settings. It also provides detailed income and family size information, making the poverty level of a given household easy to determine. The ACS also includes a poverty status recode for every individual in the dataset. Employment information, as well as information on travel time to work and commute mode are all readily available using the ACS. In addition, the ACS allows researchers to determine the Public Use Microdata Area for each individual's home, and, if applicable, work. With this information, we can begin to develop an understanding of where in King County the poor, near-poor, and non-poor live and where they work.

Weaknesses – Although the ACS is better than the WaPop at telling us where people in different income groups live and work, it does not give us any indication about which routes those people are likely to take to get from home to work—information that would be vital in determining the likely effects of tolling on poor populations.

Conclusions – The ACS is similar to the WaPop in that it provides good information about how employment levels, commute modes and commute times do or do not differ among our three income groups. It has the added benefit of providing a relatively clear picture of where the poor, near-poor and non-poor live and work. Despite these many positive aspects however, the lack of information regarding the routes that members of different income groups take to get to and from work makes this dataset less useful than it could be for the purposes of this study.

Household Activity Survey (2006)

Dataset and Sample Descriptions - The 2006 Household Activity Survey was commissioned by the Puget Sound Regional Council with the goal of providing information on why households make the choices that they do regarding travel behavior. The survey of 4,700 households in King, Pierce, Kitsap and Snohomish counties was conducted in the spring of 2006. 2,699 of the surveyed households were in King county. Of those, 147 were likely to be poor.

Strengths – For the purposes of our study, one of the most interesting features of the HAC is that it includes exact (longitude and latitude) home and work information for over 4,686 individual respondents. We first mapped those home/work pairs using GIS and then developed an algorithm to determine the most likely route between each pair. In this way we are able to tell exactly which respondents would be most likely to use a route that could be tolled in the future.

Weaknesses – While the HAS is excellent for determining who in the sample has the most chance to use a route that may be tolled in the future, it is not very good at telling us much about the economic status of those individuals. In the dataset, household income is divided into $10,000 bins, which makes it very difficult to place households and individuals into categories of poor, near-poor, and non-poor with any sort of certainty. As an illustration, there were 3,165 employed persons in the King county sample. Of those, only 23 could be counted as poor (100 percent of FPL or below). For another 69 people, it was impossible to tell.

In addition, the survey was designed to give an accurate representation of the distribution of travel modes in the Puget Sound Region, not the distribution of income within each mode. This means that while considerable care was taken to oversample transit users, for example, similar care was not exercised in the sampling of poor and low-income households. The result is that knowing that 25 out of the 250 people who are likely to cross the SR 520 bridge happen to be poor or near-poor does not necessarily mean that 10 percent of those crossing the SR 520 bridge are poor or near-poor.

Conclusion – The level of geographic specificity available in the HAS is unmatched and potentially allows the researcher to perform some very interesting analyses. However, the fact that income distribution was not a priority in the sampling, along with the broad income categories, make this dataset less than ideal for evaluating the potential effect of tolling on low-income populations.

Final Thoughts

While each of the three datasets we evaluated for this study was found wanting, we were able to combine the information they contained to glean some understanding of the distribution of the poor, near-poor, and non-poor in King County, their commute modes, and the length of their commutes. We can even make some guesses about which routes individuals in our three income classes are likely to take. Perhaps more importantly, however, the exercise was useful in helping to shape our ideas about what kind of data would allow us to answer the question of how tolling would affect low-income populations in the Puget Sound Region. Future research efforts should concentrate on developing a dataset that includes the following elements:

- A relatively large sample
- Representative sampling of all income groups in the Puget Sound Region. Oversampling of minority populations.
- Fine grained income information for all households in survey
- Household size
- Geographic information—where do people live? Where do they work? Preferably at the census block level
- Employment status
- Respondent’s commuting routes
- Commuting modes
- Information on why people chose that mode

Appendix C: Route Analysis Procedures

For our analyses, we used the Household, Person, and Workplace datasets in the Household Activities Survey. Data worked followed these steps:

1) We assigned each individual a Unique ID, based on their household identification number (qno) and their person number. For example, if an individual is lives in household number 2011 and is the second person in that household, his or her Unique ID would be 20112. The variable, Unique_ID was added to the Person and Workplace datasets.
2) Home and workplace location coordinates for each worker were merged from the two datasets containing that information (HH_data_xy_v4.sav , and Wkplace_data_xy_v4.sav) to the Workplace dataset.
3) The resulting dataset was used to create a single table containing each person's Unique ID, and their home and work location.
4) Using GIS, we plotted home and work locations for the 4,685 workers out of 5,352 for whom we had both home and work locations.
5) An algorithm was developed in GIS to assign the most likely route between each home/work pair based on 2003 Tele Atlas streets data. Each assigned route was individually checked against Google Maps for validity, and where it did not make sense, was corrected.
6) We then broke down the major routes in King County/ South Snohomish County into 12 sections, and determined which respondents passed through each section using GIS. That information was the basis for a new dataset, Routes.sav, which contained the Unique ID and yes/no variables for each of the 12 routes.
7) Using the Unique ID variable, Routes was merged with the Workplace dataset.
8) Poverty Levels
    a. In the meantime, a new variable called "Poverty Level" was created in the Household dataset, and a rough poverty calculation was made for each household using the family size and income information. Because the income figure for each household was in $10,000 increments, we could only calculate the poverty status with certainty for a portion of the

households. These were either labeled “Poor”, or “Not Poor.” The remaining households were assigned to a category called “May be Poor.”

   b. We wanted to perform analyses under two assumptions:
      i. That all of the households in the “May be poor” category were actually poor
      ii. That all of the households in the “May be poor category were actually not poor
   c. To that end we created two new 0/1 dichotomous variables—“If Poor,” and If Not Poor.”
   d. Using the same methods, we created new variables called “Low-income level (Households were either assigned to a “Low-income” category, a “Not Low-income” category, or a “May be low-income” category.),” “If Low-income,” and “If not Low-income.” For our purposes, a household that is low-income is at 200 percent of the Federal Poverty Level or below.

9) The Household dataset was merged with the Person dataset using the Household ID (qno) variable. The resulting dataset was then merged with the Workplace dataset using the new Unique ID variable. This final dataset had poverty information for each respondent, as well as work route information for 4,685 respondents.
10) Two new variables were created
   a. Num_Tolled – the number of possible tolled sections a person would need to pass through in order to reach work or home was computed.
   b. Tolled_Route – a 0/1 dichotomous variable in which 0 indicates that a person does not pass through any potentially tolled route, and 1 indicates that a person passes through one or more potentially tolled sections.
11) Other new variables include:
   a. Commute_Mode – The Workplace dataset had 8 variables to describe commute mode (wmode1 – 8) We collapsed these into one variable, Commute Mode, with the following values:

      1 = Car Alone

      2 = Carpool

3 = Bus or Train

4 = Bike

5 = Walk

6 = Ferry

7 = Combo (Some combination of the above modes.)

b. GIS_ID – The ID that the GIS program assigned each route.

Appendix D: "Near-poor" Results

This section contains results parallel to those presented in Section 4 but calculated for Near-poor households, those making between 100 percent and 200 percent of the poverty line. Table D.1 shows results for the Near-poor from the ACS data on car ownership and commutes. The GIS route analysis information on the Near-poor will be completed and included in the final report.

Table D.1 Employment and Commute Information by Poverty Category including "Near-poor"

(Authors calculations using American Community Survey Data, weighted to represent Puget Sound Area)

	Poor Households	Near-poor Households	Non-Poor Households
Population (%)	7.7%	11.5%	80.8%
	Characteristics of all households		
Car ownership (%)	69.3%	85.3%	96.2%
Mean number of cars	1.01	1.36	2.03
Contain one or more workers	77.3%	83.1%	91.4%
Mean number of workers	.99	1.23	1.69
	Commute characteristics of workers (individual level)		
Mode			
Drives Alone*	60.9%	71.9%	75.1%
Carpools*	8.1%	7.4%	8.7%
Public Transportation*	18.5%	10.1%	6.9%
Other Commute Mode*	12.4%	10.7%	9.3%
Commute time in minutes*	28.2	26.1	28.9

*Differences between low-income (poor and near-poor) vs. non-poor are all significant at a 95% confidence interval.