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**Analyzing the Impact of Highway Tolls on Low-Income Persons:
An Application to the Puget Sound Region of Washington State**

Robert D. Plotnick
Evans School of Public Affairs
University of Washington
E-mail: plotnick@u.washington.edu

Jennifer Romich
School of Social Work
University of Washington
E-mail: romich@u.washington.edu

Jennifer Thacker
Matthew Dunbar
University of Washington

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Abstract

Tolls are an increasingly popular policy tool for achieving functionality, affordability and environmental responsiveness in urban transportation systems. Alongside their benefits, tolls' impacts on equity require scrutiny. Prior studies of road users find that tolls are regressively distributed, costing low-income households a higher percentage of their income than wealthier households. Using data from the Puget Sound metropolitan region in Washington State, we advance the literature by 1.) using Geographic Information Systems methods to map commuting routes, and then 2.) simulating the effects of possible toll regimes on different universes of households, including those who use tolled facilities as well as those who do not. By omitting the many low-income households without workers or who commute using public transportation or untolled routes, prior studies overstate tolls' regressivity. We find that tolls are regressive but the degree of regressivity is sensitive to the set of households included in the analysis.

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INTRODUCTION AND BACKGROUND

In planning regional transportation systems, policymakers balance overlapping and sometimes competing goals of effectiveness, cost-efficiency, environmental responsibility and social equity. The increasingly popular strategy of tolling drivers on new or previously untolled facilities has implications for all these goals, and is one strategy among others for creating systems that can best move persons and goods through metropolitan areas.

In an era of limited state and local budgets and legislators' reluctance to support higher fuel taxes or general tax increases, tolls on urban highways and bridges may be an attractive source of funds for construction and maintenance of transportation infrastructure. Urban policy makers are also gradually accepting well known arguments in the transportation research community that well designed tolls can help reduce congestion and air pollution by giving residents incentives to use the highway system more efficiently. The most current federal surface transportation act, the 2005 Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (Public Law 109-59; SAFETEA-LU), gave metropolitan planning organizations greater leeway to use congestion-based tolls as a strategy for reducing total miles driven. New or newly-tolled facilities now operate in California, Texas, Virginia and other states (Bhatt et al. 2008).

Along with tolls' efficiency and revenue-raising benefits, their impacts on equity have become an important part of the debate about their appropriate use. Critics raise concerns that tolls are regressively distributed—costing low-income households a higher percentage of their income than middle or upper income households. More broadly, policy makers should consider possible equity impacts of tolls alongside other spatial and transportation topics with implications for low-income residents of metropolitan regions. For instance, for low-income workers who do not live close to employment centers, tolling could exacerbate spatial mismatch (Kain 1992) by further increasing commuting costs. Debates over tolling regimes in Europe—where tolling is more widely used—focus in part on whether tolling constitutes a mechanism of social exclusion whereby lower-income residents are less able to fully participate in normal social activities such as using public roads (Bonsall and Kelly, 2005).

This study contributes to the debate about tolls' equity impacts by examining the potential economic costs of tolling for low-income and non-low-income households. Using data from the Puget Sound metropolitan region in western Washington State, we examine car ownership and transportation patterns among low-income and non-low-income households. Using a simple simulation we confirm earlier findings that the financial costs of tolls are regressively distributed. We further show that these costs differ markedly among low-income and non-low-income households depending on whether and where household members drive.

The analysis improves on past research in two major ways. To our knowledge it is the first to use Geographic Information Systems (GIS) methods to map driving routes from home to work in order to model possible tolling schemes. We determine the extent to which low-income households commute on highway segments that may have tolls in the future and compare how frequently low-income and non-low-income households commute on each segment.

Second, prior studies generally examine only drivers who use tolled facilities and occasionally drivers who do not use tolled facilities. By omitting the many low-income households without workers, or with commuters who do not use private vehicles, such studies overstate the effect of tolls on the entire low-income population. We follow standard practice of estimating tolls' potential impact only on households with workers who would drive on tolled and non-tolled facilities. We then redo the analysis including broader groups of households. We find that the degree of regressivity is quite sensitive to the set of households included in the analysis. These results suggest that distributional analyses of tolls should estimate impacts on all households in the relevant region in addition to impacts on just users of roads that are currently tolled or likely to be tolled. Doing so would accord with standard practice in distributional studies of taxes and income support programs and would offer more insight into how highway tolls may affect region-wide equity.

The remainder of this article has five sections. Section 1 reviews the literature on how tolls affect equity, including what is known about tolls' impacts on the financial status and driving time of low-income households and on low-income households relative to middle and high income households. Section 2 describes the data set, which contains information about current residential and work locations of each household. It also describes a novel methodology for exploiting this unusual information that uses geographic-specific routing analysis to map current commuting routes. Section 3 first provides data on employment, car ownership, commute mode and commuting routes of low-income and non-low-income households. It then presents estimates of potential tolls' cost to low-income and non-low-income households. Though results apply only to the Puget Sound region of Washington State, the study's methods can be applied in any region where suitable data exist. Section 4 discusses the limitations of the empirical analysis. It also outlines data collection and methodological strategies for future research that would yield better estimates of the equity impacts of tolling. The final section compares the findings to earlier research and discusses the additional information gained when the analysis moves beyond users of tolled facilities to analyze more inclusive sets of households.

SECTION 1: LITERATURE REVIEW

Assessing the income equity of a tolling regime requires analysis at several different levels. An initial question is: what are the regime's likely financial and time impacts on low-income households? Financial impacts include how much a typical low-income household would spend on tolls per year, the share of income spent on tolls, and how this spending might affect consumption of other goods and services. Time impacts include how much time low-income households would save because of congestion tolls or whether their travel time would increase as they shift to public transportation or to non-tolled but longer or more congested alternative routes. The financial and time impacts for low-income households must then be considered relative to those for middle and high income households. A related issue is whether the payment methods, deposits, and service fees required by the collection technology (commonly an in-vehicle transponder) would disproportionately curtail low-income households' access to transportation facilities.

Equity considerations also require looking within and across different types of households. Low-income households are heterogeneous and will hence be affected differently by tolling policies. A current low-wage worker who commutes daily via highways will be affected more than a non-worker or someone who currently walks to work. A final set of concerns around the net distributional effects revolves around the poor as a class or group. To determine whether low-income households generally experience benefit or detriment from a tolling regime, analysts must consider the full policy system, including revenue flows in the absence of a tolling regime and uses of toll revenues.

Facility- and Population-Specific Factors

Answers about how much poor and non-poor persons will pay are necessarily project-and location-specific because they depend on the facilities subject to tolls, whether constant tolls or congestion tolls are imposed, the amount of the toll (and, 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. Analysis must consider population characteristics such as car use, employment and residential patterns. Differences among low-income households in whether they drive, whether and how they commute to work, and how far they live from work imply that the impacts of tolls will not be borne equally.

Tolls will mostly strongly affect car owners. Pucher and Renne (2003) use the 2001 National Household Travel Survey to examine travel patterns of low-income households (incomes below $23,000 in 2006 dollars).[1] More than 26 percent of low-income households do not have a car, compared to five percent of households in the next income level and less than two percent of households making more than

[1]Every study that we reviewed uses an income higher than the official federal 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, our discussion of each study uses the terms "poor" and "low-income" as defined by its author, not by the official poverty measure.

$114,000 (2006 dollars). 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 low-income households with no car report considerable auto use (34 percent of all trips in 2001), usually as passengers in someone else's car. Low-income households use cars for roughly 75 percent of their trips and public transit for only 4.6 percent of their trips. These figures are consistent with an earlier and frequently cited study by Murakami and Young (1997) which found that 84 percent of low-income households' trips to work are made in private vehicles.

Employment patterns matter because travel to work is the least discretionary and the most likely to be tolled. Most low-income households contain at least one employed member, but the percentage with workers is lower than for more affluent households (U.S. Census Bureau 2009a). Where poor and non-poor workers live relative to employment opportunities is another consideration. Although residential segregation by race has decreased over the 20th century, segregation by income level is both persistent and increasing (Jargowsky, 1996, Massey, Rothwell, and Domina, 2009). Poverty is distributed unevenly over different neighborhoods, with areas of concentrated residential poverty giving rise to worries about spatial mismatch, in which low-income workers live away from employment areas. Nationwide, poverty is increasing fastest in suburban and exurban areas (Kneebone, 2009). The distributional effect of a given toll regime will vary depending on whether it tolls routes between areas of greater or lesser poverty.

Findings on How Tolls Affect the Economic Well-Being of the Poor

Prior research suggests that tolling—in general—is regressive, but distributional impacts are rarely the sole focus of studies on tolling. A rigorous assessment of a tolling project's equity impacts 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. Most tolling research falls into one of two categories: projections of effects of hypothetical tolling regimes or analyses of observed outcomes following enactment of tolls. Table 1 lists previous studies and summarizes their implications or findings about the

TABLE 1
Previous Studies' Findings on Distributional Effects of Tolls

Study	Geographic Area	Focal Tolling Regime	Findings on Distributional Effects or Effects on Lowest Income Groups
Small (1983)	San Francisco Bay Area	Hypothetical toll of $1.25–$10.00	• Lowest income group ($0–46,000 in 2005 dollars) has the largest absolute losses • Net benefits inversely related to income
Giuliano (1994)	Los Angeles region	Hypothetical toll of $0.15/mile	• Low and middle income commuters would lose unless they could change their mode of travel to avoid a toll
Sullivan (2000, 2002)	Orange County, CA	Observation of SR 91 congestion tolling	• Use of tolled facility is positively correlated with income • Work schedule flexibility appeared to be unrelated to use of I-15 tolled express lane
Supernak et al. (2002)	San Diego area	Observation of I-15 congestion tolling	• Tolled express lane users are more likely to be from higher income households than non-users.
Safirova et al. (2003)	Northern Virginia	Hypothetical conversion of HOV lanes to tolled and HOT lanes (High Occupancy Transit)	• All income groups would benefit from the conversion. • Wealthier drivers' net benefits would be 27 times greater than those received by drivers from the poorest quartile, largely due to value of time
Burris and Hannay (2004)	Houston area	Observation of HOT lane users and non-users on Katy Freeway	• Average usage of HOT lanes was not related to income among all users. • Insufficient sample size to compare low-income users to others
Safirova et al. (2005)	Washington DC	Hypothetical cordon or link-based tolls	• Both tolls can provide a net benefit to all users as a whole • Without revenue recycling, both tolls create losses for the lower 3 income quartiles; losses are disproportionately high for lowest income quartile
Franklin (2007)	Seattle area	Hypothetical bridge toll	• Toll is regressive • Toll more regressive when time taken into account
Puget Sound Regional Council (2008)	Seattle area	Experiment with variable charge for road use	• Responsiveness to price is inversely related to income • Higher income household pay more in tolls, while lower-income households reduce trips, switch mode, or spend longer in travel

distributional effects of tolls on low income populations. It does not include studies with no data on income.

Small (1983) modeled the equity effects of three hypothetical peak expressway tolls. In his study, when the toll's financial cost and 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, a finding that is echoed in later studies that project possible effects based on current (non-tolled) travel patterns.

Small's important early study illustrates later conclusions about the literature as a whole. According to Richardson and Bae (1996) and Giuliano (1994), two 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, and 2.) Low-income drivers and those who choose to no longer using the tolled routes suffer losses.[1]

Less is known about observed behavior in response to an actual toll. Three studies—Sullivan (2000, 2002) and Buris and Hannay (2004)—use observational data from enactment of congestion tolls or HOT lanes (high occupancy tolled lanes, which allow single drivers to pay a premium to use high occupancy vehicle lanes). All three find that usage of HOT lanes is positively correlated with income, but none of the studies have sufficient sample size to compare low-income users to others.

Transaction costs and mechanisms can restrict access as well. 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. Parkany (2005) found income is positively related to transponder ownership, toll road use, and frequency

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[1]Eliasson and Mattsson (2006) similarly conclude that tolls are most likely to be regressive 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.

of use. Burris and Hannay (2004) speculate that the costs of purchasing and maintaining a transponder may have made the Houston QuickRide prohibitively expensive for some low-income drivers.

Revenue Use and Alternative Funding Sources

Analysts generally share the view that toll's negative impacts on low-income drivers could potentially be offset by how the revenues are used (Small 1992, Santos and Rojey 2004, Safirova et al. 2005, Eliasson and Mattsson 2006). While it may be possible, in principle, to redistribute the revenue so that all income groups gain, there are substantial political and administrative obstacles to doing so. Redistribution of revenues on a per-capita basis or according to income can make all users better off and counteract the regressivity of tolls (Small, 1983; Franklin, 2007). However, none of these schemes have yet been implemented, and under any redistribution plan, some low-income individuals who are constrained to certain travel routes will be worse off.

While not redistributing the revenues implies that tolls are likely to be regressive, it is important to recognize the financing a project with tolls will generally impose fewer costs on low-income persons than broad based consumption-oriented taxes such as the gas or sales tax (Schweitzer and Taylor 2008). Since other taxes and fees may well be equally or more regressive than tolls, to fully assess the equity effects of tolling one must compare tolls' effects to those of an alternate financing method in a no-toll scenario (Franklin 2007, Weinstein and Sciara 2004).

SECTION 2: DATA AND METHODOLOGY

The literature review identified factors needed to evaluate the impact of tolling on low-income populations: a) car ownership, b) employment, c) post-toll travel patterns, d) economic impacts due to pricing, e) impacts due to collection mechanisms and f) larger revenue considerations. Our empirical strategy deals with three of these: car ownership, employment, and pricing impacts. Using a unique geographic-specific routing analysis, we map current commuting routes and make the assumption that they are the best possible estimate of post-toll travel patterns. We draw on this mapping to estimate the impact of potential tolls on low-income and non-low-income households in the Puget Sound region.[2]

This method assumes that tolls do not affect current commuting patterns. We make this assumption in view of data limitations. 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.

Definition of Low-Income

This analysis defines low-income persons as those living in households with income at or below 200 percent of the official federal poverty line. The official poverty line uses a set of dollar value thresholds that vary by family size and composition, but not geographically. The U.S. Census Bureau annually updates the thresholds for inflation using the Consumer Price Index for All Urban Consumers (CPI-U). In 2009, the official threshold for a family of three was $18,310. For four, it was $22,050.

We examine low-income persons rather than officially poor persons for several reasons. First, critics argue that the federal poverty thresholds are too low, particularly in high-cost areas such as the Puget Sound (Blank, 2008; Pearce and Brooks, 2001). Second, a number of important programs that assist needy persons implicitly acknowledge that the official thresholds are too low by setting their income eligibility thresholds higher than the official poverty line by as much as 300 percent (e.g. Head Start, food stamps, School Lunch Program, State Child Health Insurance Program). Third, the small number of officially poor households in the study's key data file would lead to imprecise estimates. Last, near-poor households share many characteristics with poor households that contain workers. Research shows that many households that are poor in one year may become near-poor the next year and vice versa as household income fluctuates (Cellini, McKernan, and Ratcliffe, 2008). Because households with workers are those that commute, looking at both poor and near-poor may be more informative.

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[2]Since collection mechanisms and other revenue issues can only be evaluated in the context of a specific tolling plan, these factors are beyond the scope of this study.

Data

The study uses two data sets. Descriptive information about the low-income population, employment, travel time to work, car ownership, and commute mode comes from the 2007 American Community Survey (ACS) Public Use Microdata Sample files for Washington State's Puget Sound region: King, Pierce, Snohomish and Kitsap counties. This data set includes 34,106 individuals in 14,911 households. The findings we report use the sample weights, so they are representative of the population at large.

The key data set is the Puget Sound Regional Council's 2006 Household Activities Survey (HAS). The Council commissioned the HAS to provide information on why households make the choices that they do regarding travel behavior. The survey includes 4,746 households in the Puget Sound region.

Mapping Commuting Routes. One of the HAS's most valuable features is that it includes both basic demographic information and exact (longitude and latitude) home and work location for nearly all employed respondents. To map workers' commuting routes, we merged the demographic and latitude-longitude information into a GIS database. We created and applied a mapping algorithm that assigned the most likely route between each home and work pair. We manually checked assigned routes against Google Maps to identify implausible routes, and made hand edits as needed. This route information captured the distribution of commuting trips on both major and minor roads. By combining the route and demographic information, we were able to identify low-income and non-low income workers most likely to use routes that may be tolled in the future.

Limitations of the Household Activities Survey. The HAS has two important limitations. It was designed to accurately represent the distribution of travel modes in the Puget Sound Region, not the distribution of income of users of each mode. Considerable care was taken to oversample transit users. Similar care was not exercised in sampling poor and low-income households and, consequently, they are underrepresented.

Second, the data on income is weak. Household income is reported in broad categories—< $10,000, $10,000–19,999, etc. This crude measure makes it difficult to categorize some households as low-income or not with certainty.

We dealt with this problem with a simple procedure best explained by example. Consider a family of four with two children. Suppose it reported a 2006 income in the $30,000–39,999 range or a lower one. Since 200 percent of that family's 2006 poverty line was $40,888, we can unambiguously classify it as low-income. If its reported income was in the $50,000–59,999 range or higher, it is unambiguously non-low-income. If its income fell between $40,000 and $49,999, where we cannot be certain about its low-income status, we assume it was low-income. Though this procedure overestimates the number of low-income families, since the error can never exceed $10,000 we know that all these ambiguous families are not financially well off.

Notwithstanding the HAS's limitations, its detailed data on home and work location provide a valuable but rarely available resource for understanding the distributional effects of tolls.

SECTION 3: EMPIRICAL FINDINGS

This section presents new evidence about car ownership, employment and travel patterns.

Low-Income and Non-Low-Income Populations in the Puget Sound Region

In 2007 19.2 percent of all households in the four county Puget Sound region fell below twice the poverty line. The corresponding national rate was 32.8 percent (U.S. Census Bureau, 2009b). The region's lower rate likely reflects its higher wage rates and better-than-average economic conditions at that time.

Employment, Car Ownership and Commute Mode

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

Table 2 shows information on employment and commuting among Puget Sound households below and above twice the poverty line. Eighty-one percent of low-income households and 91 percent of non-low-income households contain at least one worker. Seventy-nine percent of low-income households and 96 percent of non-low-income households own at least one car. On average, a low-income household owns 1.2 cars and a non- low-income household owns 2.0.

Workers who currently commute via single occupancy vehicles are likely to be most affected by any new tolling regime. The bottom panel of Table 2 shows commute mode. Driving to work alone is most common, with 63 percent of low-income individuals and 73 percent of non- low-income individuals commuting in this way. Low-income workers are slightly more likely to carpool than non-low-income workers (13.1 vs. 11.1 percent), and more likely to use public transportation (12.8 percent vs. 6.9 percent) or other modes such as walking or biking (11.2 vs. 9.3 percent). On average, low-income persons spend 24.6 minutes commuting, or about two minutes less than non-low-income persons.

Table 2 confirms what other research has demonstrated: low-income persons in the Puget Sound Region are less likely than their non-low-income counterparts to use a personal vehicle to get to work, although considerably more than half still manage to do so. Low-income persons are more likely to commute via public transportation or other modes that would not be subject to tolls. These facts imply that tolling is likely to affect a smaller percentage of low-income persons than non-low-income persons in the region.

Table 2
Employment, Car Ownership and Commuting Mode by Low-Income Status

	Low-Income Households	Non-Low-Income Households
Percent of regional population	19.2%	80.8%
Characteristics of Households		
Contain one or more workers*	81.0%	91.4%
Mean number of workers*	1.14	1.69
Car ownership (%)*	78.9%	96.2%
Mean number of cars*	1.22	2.03
Characteristics of Workers		
Commuting Mode		
Drives alone*	62.9%	72.3%
Carpools*	13.1%	11.1%
Public transportation*	12.8%	6.9%
Other commute mode*	11.2%	9.3%
Mean commute time in minutes*	24.6	27.5

Source: Authors’ calculations using American Community Survey data, N=34,106 individuals in 14,911 households, weighted to represent Puget Sound Area population.

* Significantly different at a 95% confidence interval.

Commuting Routes of Low-Income and Non-Low-Income Workers

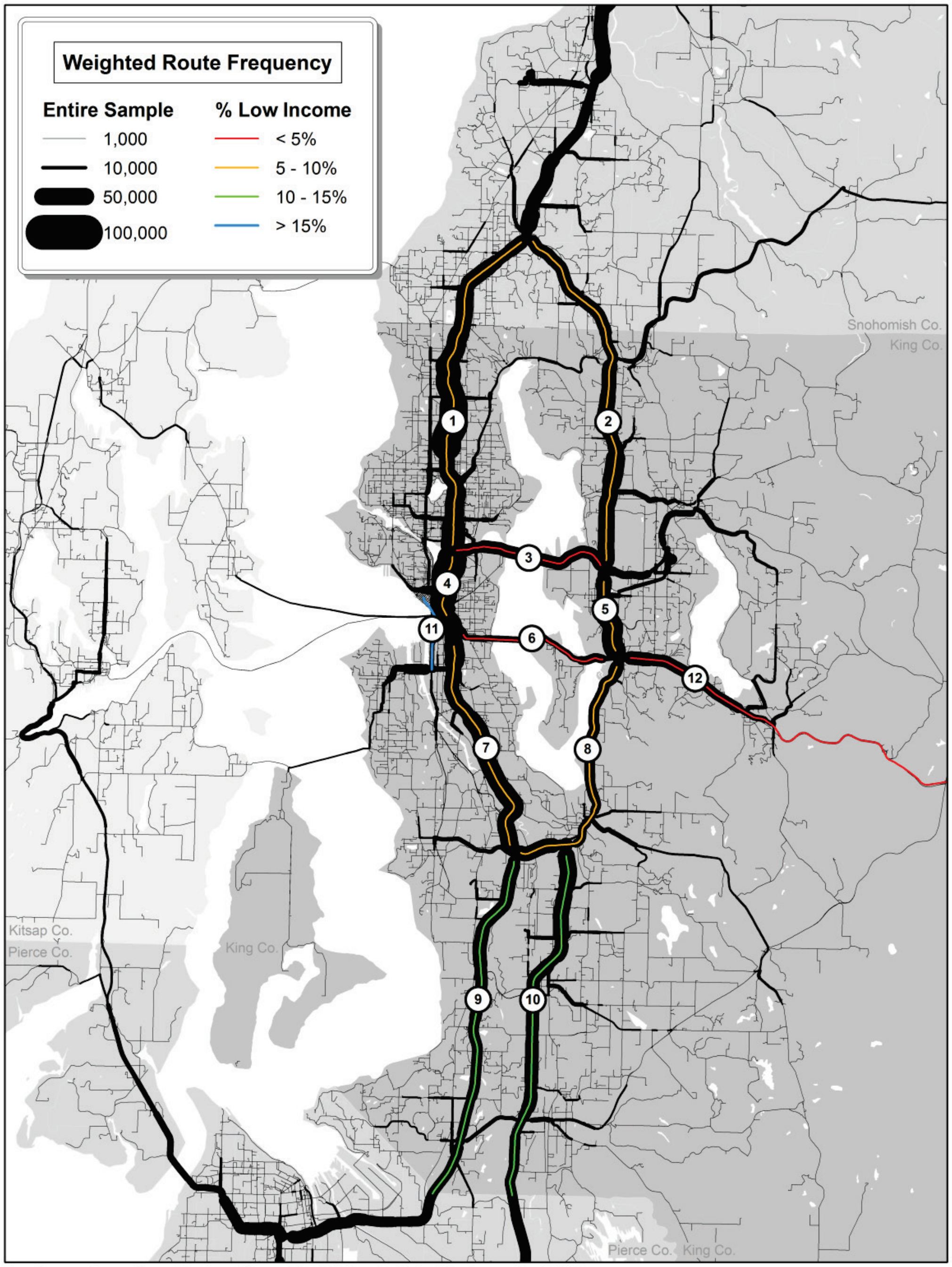
To assess the impact of different toll scenarios, we focused on 12 segments of the region's highway system for which tolls have already been discussed or implemented, or that appear to be plausible candidates for congestion tolls. Each segment extends over a different section of the six major highways in King County: I-5, I-405, I-90, SR 520, SR 167, and SR 99. Figure 1 shows all segments, which are described in table 3. They include, for example, the bridges across Lake Washington which connect Seattle and the affluent eastern suburbs (segments 3 and 6). The stretch of I-5 between its junction with I-405 on the north and SR 520 (the northern bridge across the lake) on the south is another (segment 1).

Figure 1 displays the trip density for all commuters in Puget Sound based on the routes estimated by our mapping procedure. Thicker lines indicate greater numbers of commuters on a given route. Not surprisingly, the most heavily used routes (1, 4 and 7) are segments of the interstate highway (I-5) adjacent to downtown Seattle. Shading within the lines indicates the percentage of users who are low-income. The most heavily-used routes have between 5 and 10 percent low-income drivers. On the two east-west bridges, segments 3 and 6, fewer than 5 percent of all commuters are low-income.

Figure 2, derived with the GIS methods described earlier, shows the use of the 12 segments by both low-income and non-low-income commuters. The modal low-income commuter's route includes no segments. Twenty-two percent of low-income commuters use one or two segments; only nine percent use three or more. Tolling all 12 segments, therefore, would increase out-of-pocket expenditures for no more than 31 percent of low-income commuters. Though the modal non-low-income commuter also uses no segments, 32 percent of such commuters' routes include one or two segments and 14 percent include three or more.

Column 1 of Table 3 reports the share of each segment's users that is low-income. The bottom row shows that low-income commuters account for 9.2 percent of all segment users. For segments 9-11, the shares of users with low incomes are three to twelve percentage points higher than 9.2 percent. That

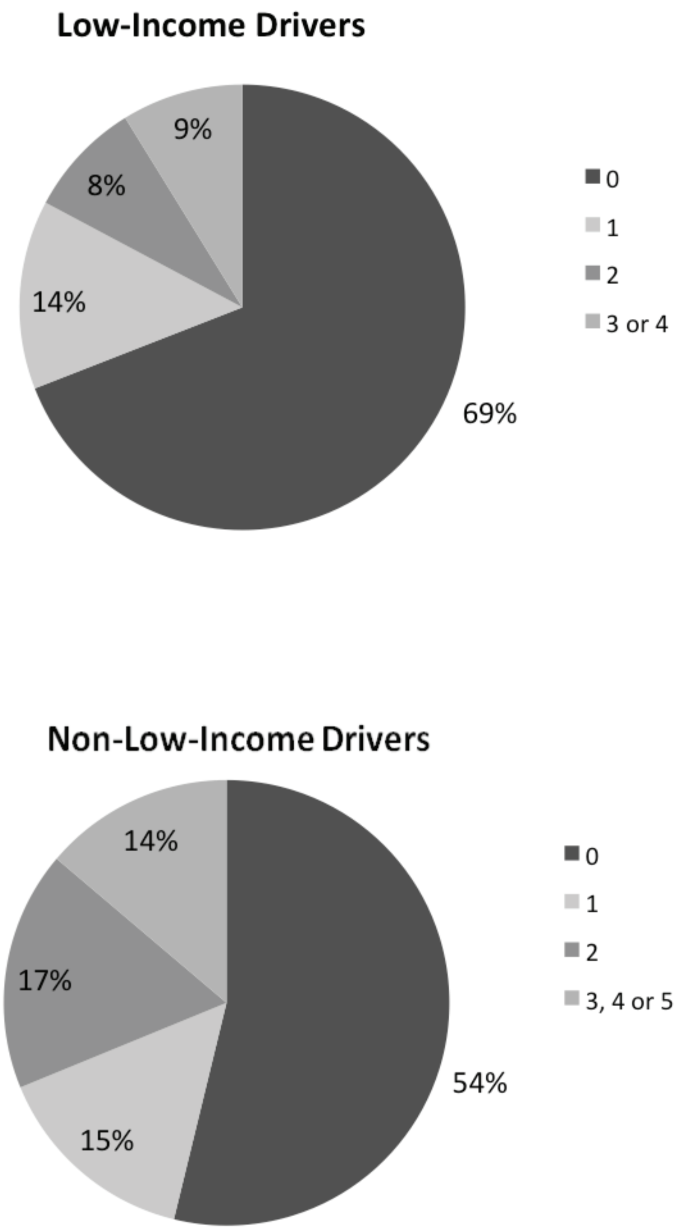
Figure 1
Route Density, All Commuters, Central Puget Sound Region



Data Source: Puget Sound Regional Council's 2006 Houshold Activity Survey (4400 HHs)

Source: Authors' calculations using the Household Activities Survey.

Figure 2
Number of Focal Highway Segments Used by Low-Income and Non-Low-Income Drivers



Source: Authors' calculations using weighted Household Activities Survey data.

Table 3
Use of Potentially Tolled Highway Segments by Low-Income and Non-Low-Income Commuters

Highway Segment	Percent of Segment Users Who Are Low-Income	Percent of Low-Income Commuters Who Use Segment	Percent of Non-Low-Income Commuters Who Use Segment
1. I-5 north from SR 520 to I-405 (serves Seattle, northern suburbs)	8.2	8.5	14.4
2. I-405 north from SR 520 to I-5 (serves Bellevue, Redmond, other eastern suburbs)	9.1	6.1	9.1
3. SR 520 bridge across Lake Washington	3.2	1.0	4.5
4. I-5 between SR 520 and I-90 (serves Seattle)	8.2	9.3	15.8
5. I-405 between SR 520 and I-90 (serves Bellevue, Redmond, other eastern suburbs)	8.0	5.0	8.7
6. I-90 bridge across Lake Washington	4.6	1.3	4.0
7. I-5 south from I-90 to I-405 (serves Seattle, southern suburbs)	7.1	5.1	10.0
8. I-405 south from I-90 to I-5 (serves eastern suburbs	10.9	7.5	9.2
9. I-5 south from I-405 to King County line (connects Seattle and Tacoma)	12.3	5.6	6.1
10. SR 167 south of I-405 junction(connects Seattle and Tacoma)	13.3	7.9	7.8
11. SR 99 from W. Seattle Bridge to tunnel (major Seattle artery)	21.9	2.1	1.1
12. I-90 east of I-405 (connects Puget Sound region to eastern WA)	3.7	1.2	4.7
All Segments	9.2	31.0	46.2

Source: Authors' calculations using weighted Household Activity Survey data. Weighted (unweighted) number of low-income and non-low-income commuters is 180,487 (283) and 1,191,605 (3,023).

is, users of segments 9–11 are relatively more likely to be low-income. The higher share of low-income users is especially pronounced for segment 11. Users of segments 3 and 6—the bridges across Lake Washington—are much less likely to be low-income. For the other seven segments, the rate of use by low income commuters is within two percentage points of the overall rate.

These findings imply that tolls on segments 3 and 6 would be less regressive than a toll on any other segment. At the other extreme, a toll on segment 11 would be most disproportionately borne by low-income commuters.

The rightmost two columns of Table 3 report the proportion of low income and non-low-income commuters that use each segment. The base for the percentages is total number of low-income or non-low income commuters, including those who use no segments. Hardly any low income commuters use the two bridges (segments 3 and 6) or segment 12.[1] Non-low-income commuters are also least likely to drive these four segments. Among low-income commuters only segments 1, 4, 8 and 10 have a rate of use greater than seven percent. No segment attracts more than 9.3 percent of low-income commuters or 15.8 percent of non-low-income drivers.[2] Tolling one or two segments would, consequently, impose financial costs on a small fraction of all low-income commuters. Tolling the two bridges, which is most practical and politically feasible, would affect less than three percent of low-income commuters.

Toll Cost Estimates for Low-Income and Non-Low-Income Households

The estimates of low-income and non-low-income households' use of potentially tolled segments allow us to project the potential annual cost of tolls for both groups and assess whether tolls would cost a disproportionate share of low-income households' income. We consider two scenarios:

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[1]Note that though only 2.1 percent of low-income commuters use segment 11, even a smaller percentage of non-low-income commuters uses it. This is why the users of segment 11 are disproportionately low-income.

[2]Since only 31 percent of low-income commuters and 46 percent of non-low-income commuters drive on one or more segments, the low use of each segment by both income groups is to be expected. If we restrict the base to the number of low-income or non-low income commuters who use at least one segment, each column's percentages will increase by the same factor (1/.31 or 1/.46), but their ratios will not change.

Scenario 1 assumes that a $1 one-way toll is imposed on all 12 focal segments listed in Table 3. We estimate the annual cost of tolls under this regime for three nested groups of households. 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 number of tolled segments used per day by low-income and non-low-income households is 0.49 and 1.25.

The second group includes only 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 low-income and non-low-income households with commuters is 0.84 and 1.48. 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 would pay tolls. The average number of segments driven per day for low-income and non-low-income households in this group is 2.07and 2.78.

Scenario 2 assumes a $2 one-way toll only on one bridge (segment 3).[3] We estimate the annual cost of this regime for the small group of households that actually use the bridge.

We compute the annual cost assuming 240 work days per year. In scenario 1 a commuter who drives roundtrip on one segment would pay $2 x 2 (roundtrip) x 240 = $960 per segment per year. We compare the financial burden of tolls for two illustrative families. One is a family with an income of $15,600, which is the median income among all low-income households. The second's income is $76,350, which is median income among non-low-income households.[4]

The upper part of Table 4 presents the results for scenario 1. Taken over all households in each group, the average low-income household would pay $235 per year, or $365 less than what a non-low income household would pay. The low-income household would pay 1.5 percent of its income for tolls,

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[3]The bridge (SR 520) is approaching the end of its engineered life span. Washington State and King County have agreed to jointly toll it to help finance its replacement. Tolls will continue to be collected on the new bridge. The average one-way toll is currently projected to be $2.16 (Seattle Times 2009).

[4]We derived these values from the 2007 American Community Survey because the income categories in the HAS are too broad to provide useful estimates.

Table 4
Hypothetical Annual Toll Burdens for Low-Income and Non-Low-Income Households

	Low-Income Households		Non-Low-Income Households	
	Annual Cost of Tolls	Percent of Income[a]	Annual Cost of Tolls	Percent of Income[a]
Full-System Tolling, $1/Segment				
All households	$235	1.5	$600	0.8
Commuting households	$403	2.6	$710	0.9
Segment commuters	$994	6.4	$1,334	1.7
SR 520 Bridge One-Way Toll Of $2				
All households	$6	0.04	$36	0.05
Commuting households	$10	0.06	$43	0.06
Segment commuters	$31	0.20	$93	0.12
SR 520 commuters	$960	6.2	$960	1.3

[a]Uses incomes of $15,600 and $76,350 (the respective median among low income and non-low-income households).

compared to 0.8 percent for the non-low-income household. The low-income household's burden is 1.88 times larger than the non-low-income household's.

Among commuting households, the average cost is necessarily higher—$403 for the low income household (2.6 percent of income) and $710 (0.9 percent) for the non-low-income household. In absolute terms low-income households pay about $300 less. The low-income household's burden has increased in relative terms. It is 2.89 times larger than the share paid by the non-low-income household.

For only those households with commuters who actually drive on tolled segments, the average yearly cost is much higher—nearly $1,000 for low-income households and more than $1,300 for non-low-income households. This cost would absorb 6.4 percent of the illustrative low-income household's income, or 3.76 times higher than the representative non-low-income household's burden of 1.7 percent.

Devoting 6.4 percent of income to tolls would force significant reductions in other types of expenditures and, hence, substantially reduce the economic well-being of low-income households whose workers commute in private vehicles. In the absence of specific efforts to subsidize low-income users of tolled segments, tolls would likely induce many of them to adopt less costly commuting arrangements.

The burden of tolling all segments would be highly unequal among both low-income and non-low-income households in the Puget Sound region. Low-income and non-low-income users of tolled segments would pay an average of about $1,000 and $1,300 per year. Non-users, of course, would pay nothing.

The lower part of Table 4 presents findings when only the bridge has tolls. The $2 one-way toll would cost the small number of households that use the bridge $960 per year, or 6.2 and 1.3 percent of the illustrative households' incomes. Spending almost $1,000 on tolls would certainly reduce the economic well-being of low-income users of the bridge and encourage them to seek less costly commuting arrangements. While the financial impact would be large for low-income users of the bridge, for low-income commuters overall the impact would be a negligible $10 (0.06 percent of income) per year since only one percent of them actually use this route (table 3, row 3). Similarly, since less than one in twenty non-low-income commuters would pay tolls on the bridge, the impact among all non-low-income commuters taken together would also be negligible (again, 0.06 percent of income).

SECTION 4. STUDY LIMITATIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH

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.

Because the sample of low-income households in the HAS is small, estimates of their commuting patterns are imprecise. Consequently, the projections of toll costs in table 4 are also imprecise.

The study does not estimate how potential tolls would affect driving times on tolled segments and other roads and of buses and carpools, or how these effects would differ for low-income and non-low-income households.[1] Information on changes in commuting time and its value to both low-income and non-low-income households is needed to obtain a more complete picture of the distributional effects of tolls.

The projections in table 4 assume tolls do not vary by time of day. The level and distribution of the costs of time-varying 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 low-income households. It would almost surely result in a different distribution of tolls' benefits and costs between low-income and non-low-income households, and among both types of households, compared to a toll that all users must pay.

Finally, the estimates 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

[1]Available data do not provide good estimates of route-specific commute times, meaning that any estimates of time savings would involve significant conjecture.

(need for credit card or bank account, deposits, service fees). To the extent that such changes occur, the financial costs for both low-income and non-low-income households would be lower than reported here and probably distributed differently, though the time costs would likely be higher.

We offer a simple thought experiment to examine how the findings on regressivity might differ if we could adjust for changes in routes and other commuting behaviors induced by tolls. How much would low-income households need to reduce use of tolled routes (or switch to mass transit or carpools, which would not require tolls) so that the share of their income spent on tolls equals that of non-low-income households? A situation of equal shares is usually interpreted as distributionally neutral.

Suppose that in the full-system tolling regime non-low-income households did not reduce use of tolled segments. Then, for all low-income households to pay the same share of their income in tolls as non-low-income households (0.8 percent from row one of table 4), they would need to take 47 percent fewer trips on tolled segments.[2] If we confine attention to low-income commuting households or segment commuters, use would need to decline respectively by 65 percent or 73 percent. Since a 47 percent reduction in use (much less 65 or 73 percent) seems unlikely, a full-system tolling regime would almost surely remain regressive in financial terms after low-income households adjust their driving behavior. Moreover, the burden of longer driving times necessitated by using minor roads would partially offset low-income households' financial savings and move the overall regressivity back towards the initial estimate.[3]

Future Research

We offer two suggestions for future research that would yield better information on tolls' impact on low-income populations . The first is to collect better information from surveys like the HAS, with

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[2]To derive this figure, note that 0.8 percent of the representative low-income household's income is $125. The ratio of $125 to table 4's projected cost of $235 is .53. This means usage must fall by 47 percent.

[3]If higher income households did reduce their use of tolled routes, low-income households would need even larger reductions in use to achieve distributional neutrality. For instance, if higher income households took 10 percent fewer trips on tolled segments, low-income users would need to reduce their use by 54, 69 and 75 percent.

their valuable detailed information on location. More detailed income data, like that routinely gathered by the Current Population Survey and many other widely used data sets, would substantially improve the precision of distributional estimates. Concerted effort to oversample low-income households would both increase precision and allow comparisons of tolls' impacts across important sub-groups (e.g., single and two parent families, minorities, immigrants, those with limited English proficiency).

Our second suggestion is to take advantage of the natural experiment caused by any new tolling regime by assessing tolls' impacts using a before-after evaluation design. Evaluators could recruit households into the study and observe their driving patterns before a tolling regime begins. It would be essential to recruit a representative sample from the general population of households, not only from those currently using routes that will be tolled. This would establish the baseline pattern of travel routes, modes and times. After the regime starts and households have had time to adjust their travel behavior, evaluators would observe post-toll travel patterns and the level and distribution of financial costs and travel times. Comparing pre and post-toll outcomes would provide more definitive estimates of the tolling regime's impacts, including its effects on travel time and mode.

SECTION 5. DISCUSSION

If we restrict attention to only households that drive on potentially tolled routes in the Puget Sound region, we find that tolls would absorb one-sixteenth of the representative low-income household's income. This significant burden would be 3.77 times larger than that borne by the representative non-low-income household, a substantial degree of regressivity. Narrowing the focus to households that use the one bridge that will almost certainly be tolled gives burdens of 6.2 and 1.3 percent. This raises the regressivity; the low-income household's burden would be 4.77 times larger than the non-low-income household's. This pair of findings confirms the consensus from previous research that tolls are regressive—among users of tolled facilities, the portion of income paid in tolls is inversely related to their incomes.

A more nuanced story emerges when one moves beyond the conventional focus on users of tolled facilities to analyze more inclusive sets of households. For all commuting households, regardless of whether they use potentially tolled routes, the ratio of the burdens falls to 2.89. For the broadest population—all households regardless of whether they commute—the ratio falls further to 1.88, or half the ratio when the calculation includes only households that use potentially tolled routes. As the analysis becomes more inclusive, the regressivity shrinks.

By looking beyond users of tolled facilities and including all low-income and non-low income households in the analysis, we further demonstrate that tolls are not borne equally among all low-income households, nor among all non-low-income households. Fully 69 percent of low-income households and 56 percent of non-low-income households would pay no tolls (table 3, bottom row). The 31 and 44 percent who do pay would incur significant burdens averaging 2.6 and 0.9 percent of income. Differences in whether household members drive, whether they need to commute to work, how far they live from work, and the specific roads they drive create these differences.

The lower panel of table 4 more strongly demonstrates that restricting the analysis to users of a tolled route may present a greatly distorted picture of tolls' distributional impact on more inclusive populations. Taken over all low-income commuters, the burden of the bridge toll is 0.06 percent of income. For all low-income households, the burden falls to 0.04 percent. Because low-income commuters use the bridge much less often than non-low-income households (1.0 versus 4.5 percent of commuters) and a smaller proportion of low-income households have commuters, a toll on the bridge would be distributed roughly proportionally or even slightly progressively across all households in the region.

This last finding has important implications for the choice of mechanism for financing construction of a new bridge. In the case at hand, financing via tolls on the bridge would essentially be distributionally neutral. Doing so would be more equitable than relying on the typical alternatives—sales and gasoline taxes—which are clearly regressive and would impose significant burdens on low-income households that do not use the bridge (Schweitzer and Taylor 2008).

We suggest that distributional analyses of tolls include all households in the relevant region, not just those that use roads that are currently tolled or likely to be tolled. Doing so would accord with standard practice in distributional studies of taxes and income support programs, which take into account households that pay no taxes or even negative taxes (if they qualify for refundable tax credits that exceed their federal income tax liability), or receive no income transfers. Such an approach would offer more insight into how equity effects differ within income groups, as well as between them, and how highway tolls affect region-wide equity.

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