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# The Impact of Tolls on Access and Travel Patterns of Different Socioeconomic Groups: A Study for the Greater New York Metropolitan Area

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16. Abstract
Although some argue that tolling can relieve congestion and support transportation investments, transportation equity proponents express concerns about potential adverse effects of tolling on low-income and minority travelers. With that backdrop, this study compares the characteristics of travelers who use toll facilities with those who use slower or longer alternate routes and transit modes in the greater New York Metropolitan area, consisting of 28 counties in New York State, New Jersey, and Connecticut. The study uses data from a household travel survey conducted by the New York Metropolitan Transportation Council and the North Jersey Transportation Planning Authority. The trips in the survey data were assigned to the region's road network with the ArcGIS Network Analyst so that the trips needing to pass through toll facilities on the fastest route could be identified. By using that sample of trips, the characteristics of travelers who actually used toll facilities were compared with travelers who used slower alternative routes, buses, and trains. Chi-square tests and binary logit models were used for the comparisons. In addition to showing that low-income and nonwhite travelers are less likely to use toll facilities than others, the analyses showed that low-income travelers are more likely to use alternate routes than buses and trains, while nonwhite travelers are more likely to use buses than alternate routes, but more likely to use alternate routes than trains. The models also showed significant effects of employer-based travel benefits on the selection of toll facilities, alternate routes, and transit. A separate model with only work trips showed that low-income and minority workers are more likely to use alternate routes compared to toll facilities when commuting to and from work. The policy implications of the findings are discussed.

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# 1. INTRODUCTION

## 1.1. The General Background

Highway tolling has been a controversial issue in the United States in recent years. It has attained a substantial level of attention since the mid-1990s partly because of efforts in many parts of the county to establish High-Occupancy Toll (HOT) lanes on highways. HOT lanes can be used for free by high-occupancy vehicles and for a price or fee by single-occupancy vehicles. By 2009, ten HOT lane projects nationwide were already operational and around 60 projects were at various stages of planning and development (Altshuler 2010). At present, HOT lane projects are being considered in many places with the belief that they would help to generate additional revenues that could be used to replenish deteriorating transportation funds.

Although successful toll projects can potentially generate revenues to fund transportation improvements that cannot be funded otherwise, there is also a great deal of concern about their potential effect on low-income and minority populations and communities. Since President Clinton's Executive Order 12898 in 1994, titled "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," equitable sharing of the benefits and burdens of transportation investments by low-income and minority populations has become highly important for transportation agencies (Deka 2004). In light of this Executive Order, environmental justice advocates have claimed that toll projects can impose a disproportionate burden on low-income persons by reducing their travel options and disproportionately favor the well-to-do by allowing them to travel at faster speeds.

Highway tolls can have a greater effect on low-income workers than low-income non-workers since workers have to make non-discretionary commuting trips several days a week. When jobs are not available near homes and public transportation is not available for commuting, those workers may have to drive long distances. The presence of toll facilities between homes and work places can make workers' commutes burdensome.

Job access for low-income and low-skilled workers has been a significant issue for the past several decades as a result of suburbanization of jobs and the inability of low-income workers to move to job-growth areas in the suburbs. Although the problem of accessing suburban jobs by low-income city workers has been extensively studied by researchers (e.g., Holzer 1991; Kain 1992; Ihlanfeldt and Sjoquist 1998) in the context of what has come to be known as "spatial mismatch," the effect of tolls on job access has been rarely studied. In recent years, the US Department of Transportation has shown great interest in increasing job access for workers through the Ladders of Opportunity initiative. However, significant efforts to comprehend how tolls affect employment opportunities have been lacking.

As a result of the growing concerns about the equity impacts of tolling, a report by the United States Government Accountability Office (2012) examined the potential effects of tolling on different population groups. The report concluded that despite showing significant congestion-reduction benefits, the equity impacts of tolls are still unclear. The report expressed particular concerns about inequitable impacts of tolls on low-income and minority populations due to the deprivation of public facility usage and traffic spillover from toll roads to local roads in low-income and minority neighborhoods.

Due to the concerns about disparate impacts of tolling on different population groups, the Transportation Research Board published a number of reports to guide agencies and professionals to assess and address those impacts (Zmud and Arce 2008; Mahendra et al. 2011; Perez et al. 2011; Perez et al. 2012). These reports pertain to tolling of highways in general or tolling for the purpose of congestion mitigation, often referred to as congestion pricing. The US Department of Transportation (Federal Highway Administration 2008; Burt et al. 2010; Madi et al. 2013) has also sponsored a number of studies to address the equity impacts of tolling under different circumstances. The objective of these reports has often been to provide guidance to agencies seeking to implement tolls on highway. The reports by the Transportation Research Board and the US Department of Transportation bear testimony to the increasing concerns about the potential effects of tolling on low-income and minority travelers.

Although HOT lane projects have been responsible for generating much of the recent debates about the equity impacts of tolling, cordon tolling or area-wide tolling to limit vehicular traffic within specific areas has been more controversial in this country than HOT lanes. Although cordon tolling has been successfully implemented in other parts of the world, a cordon tolling plan in New York City that would require drivers to pay a charge to drive within a central part of the city could not be ultimately implemented due to concerns in the state assembly about its regressive nature (Schaller 2010; de Palma and Lindsey 2011; Chronopoulos 2012). The plan, which promised cleaner air and increased funding for mass transportation, had substantial support from the city's residents and the real estate sector, but concerns about its potential impacts on low-income and middle-income drivers and disparate impacts on different parts of the region ultimately derailed the plan (Schaller 2010; Chronopoulos 2012; Schwartz et al. 2008).

Within the general sphere of tolling, some studies have specifically addressed existing disparities in the use electronic transponders, such as the E-ZPass in the New York metropolitan area. Disparities in transponder use has been a particularly important issue in debates about tolling since tolls are collected through transponders in all HOT lanes in this country (Ecola and Light 2009). Several studies have noted that high-income persons are more likely to obtain and use electronic transponders compared to lower-income persons (Munnich Jr. and Buckeye 2007; Ungemah 2007; Taylor et al. 2010). Parkany (2005) maintained that transponders can save time for travelers and users often pay a discounted toll, but many low-income people cannot obtain them because of the need for credit cards or bank accounts. Equity advocates continue to point to the lack of credit card access for low-income persons when opposing toll projects.

Although many studies have expressed concerns about the equity impacts of tolling, some stated preference surveys have shown that low-income persons are equally in favor of tolls as high-income persons. Halvorson and Buckeye (2006) mentioned a 2004 survey in Minnesota where persons with household income less than $50,000 and persons with household income more than $150,000 had equal preference for a HOT lane project. Similarly, Ungemah et al. (2005) mentioned surveys from the early 2000s in Southern California and Colorado where large proportions of low-income persons (defined as persons from households with income less than $40,000 and $35,000, respectively) were mostly supportive of HOT lane projects. Low-income persons could be supportive of tolls if they had alternative travel options, such as inexpensive public transportation, that allowed them to avoid toll facilities. However, another explanation for apparent low-income persons' support for tolls in past studies could be the way low-income persons were defined in the surveys. Since median household income in

the US in 2000 was only $42,148, one can question whether $35,000 or $40,000 is truly reflective of low-income households' income (DeNavas-Walt et al. 2001).

One can also question the survey results in past studies showing support for tolls from low-income persons based on a review of projects by Plotnick et al. (2010). It showed that in most cases, a significantly lower proportion of low-income persons pay toll compared to higher-income persons. There is thus a contradiction between stated preference studies where low-income people support tolls but in reality they show a lower propensity to use toll roads. This contradiction between stated and revealed preferences provides an impetus for additional research to compare the actual propensity to use of toll facilities by low-income persons. Low-income persons may be supportive of, or indifferent to, tolls if they have no reason to use toll facilities because of their typical trip origins and destinations. However, if they perceive that their travel would be adversely affected, they should be more likely oppose tolls compared to high-income persons.

Many studies have provided recommendations for addressing equity concerns related to tolling (Ecola and Light 2009, 2010; Weinstein and Sciara 2006). In addition to suggesting strategies such as engaging potentially affected communities throughout various stages of projects and equitable redistribution of toll revenues, the studies have suggested alternative travel options for affected populations, such as transit improvements and transit credit. Rosenbloom (2010) suggested forgiving tolls or allowing discounted monthly passes, while Ungemah (2013) proposed mechanisms by which people without credit cards or bank accounts could obtain transponders with a minimum cash outlay.

In different parts of the country where tolls have been proposed, efforts have been made to comprehend the effects of tolls on different population groups. Surveys have also been conducted of people who might be affected by the introduction of tolls. However, when surveys are conducted to examine the potential effect of a proposed action, such as the addition of a new toll lane or the conversion of an existing general purpose highway lane to a HOT lane, the results are hypothetical since the survey respondents express their opinions without actually experiencing the result of the action. If the survey respondents were asked about real-life experiences, the results would be more reliable, but most recent toll-related surveys have been conducted in the context of proposed toll projects instead of existing tolls.

Although surveys on people's views on existing toll facilities instead of hypothetical toll facilities could potentially lead to the development of equitable transportation policies, such surveys are rare. Exclusive surveys to inquire about people's propensity and frequency of using toll facilities are also rare. However, metropolitan transportation planning agencies sometimes include questions in surveys inquiring if travelers paid a toll while making specific trips. Although information collected from such surveys is useful to compare differences in socioeconomic characteristics of toll payers with others, data from such surveys cannot be used without screening to examine if low-income and minority persons avoid paying tolls by taking longer routes or using public transportation since toll facilities do not exist between the origins and destinations of most trips. Such data can be used only if the trips can be restricted to only those that would encounter toll facilities between origins and destinations.

In sum, there is a general agreement among transportation planners and professionals nationwide that it is appropriate to examine the effects of tolls on different population groups, especially the populations addressed by the President's Executive Order 12898. Reports by the

Government Accountability Office, the US Department of Transportation, and the Transportation Research Board show the importance of such investigations. However, the effects of tolls on people's travel patterns were rarely studied by conventional spatial mismatch studies that focused on travel barriers of low-income and minority populations. Although studies have been conducted in recent times on potential effects of tolls, many of those studies are based on hypothetical scenarios. As a result, little is known about low-income and minority populations' reaction to existing tolls, especially their propensity to use alternative roads and other transportation modes that allow them to avoid toll facilities.

### 1.2. The Significance of Tolls in the Greater New York Metropolitan Area

Tolls have existed in the New York metropolitan area for decades. Unlike residents of other parts of the country where tolls are being considered or implemented only in recent times, the residents of the New York area are accustomed to toll facilities.

The location of tolls in the greater New York metropolitan area is shown in Figure 1. The area shown in the map covers two counties of Connecticut, 14 counties of New Jersey, and 12 counties of New York State. Several major highways in the region, including the New Jersey Turnpike and the Garden State Parkway in New Jersey and the New York Thruway in New York State as well as a number bridges and tunnels are tolled. While tolls are common in New Jersey and New York City, Connecticut has no toll facilities. Connecticut residents pay toll only when they travel to the areas south, in New York and New Jersey.

Tolls at all locations in the area can be paid by E-ZPass or cash. Toll rates are distance-based on some highways like the NJ Turnpike but are fixed on other highways like the Garden State Parkway. On some highways, bridges, and tunnels, rates are higher in peak periods than in off-peak periods. Toll rates are the highest at the Hudson River crossings (e.g., Lincoln Tunnel, George Washington Bridge, etc.). In 2011, the time for which travel data are used in this research, the cash toll rate per car at the Hudson River crossings at any time of the day was $12.00. Toll rates for E-ZPass users varied by time of day. In peak periods, they paid $9.50 and in off-peak periods they paid $7.50.

Figure 2, Figure 3, and Figure 4 are presented to demonstrate how jobs and workers are separated by tolls in the study area. These figures show the central part of the study area and exclude Connecticut since there are no toll facilities in that state. Figure 2 shows how jobs are distributed over space in the study area. It shows that tolls are present around most areas with high concentration of jobs, especially in northern New Jersey and Manhattan.

Figure 3 shows jobs to workers ratios in the study area. Jobs to workers ratio is a more appropriate measure than jobs alone to examine potential effects of tolls on job access for workers since areas with a high ratio have more jobs than workers and areas with a low ratio have more workers than jobs. When tolls are present between areas with low ratios and areas with high ratios, one can see why tolls may act as barriers to workers accessing areas with high job concentration. Figure 4 shows a close-up view of the study area's central part to demonstrate how tolls at the Hudson River crossings separate New Jersey from high job-density areas in Manhattan (and also to a lower extent, areas in Queens and Kings Counties).


Figure 1. Location of Tolls in the Greater New York Metropolitan Area

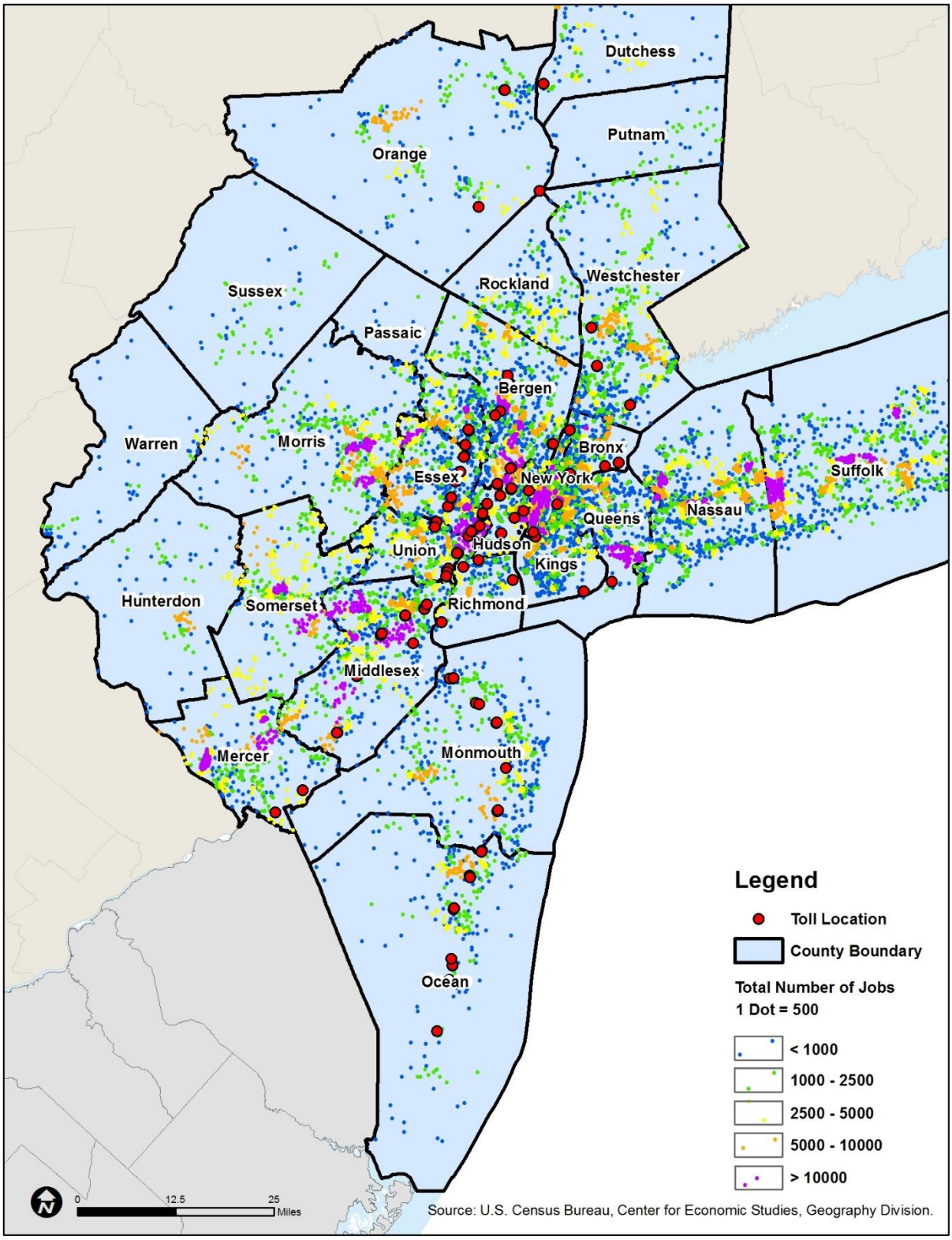


Figure 2. Jobs in Relation to Toll Locations in the New York Metropolitan Area

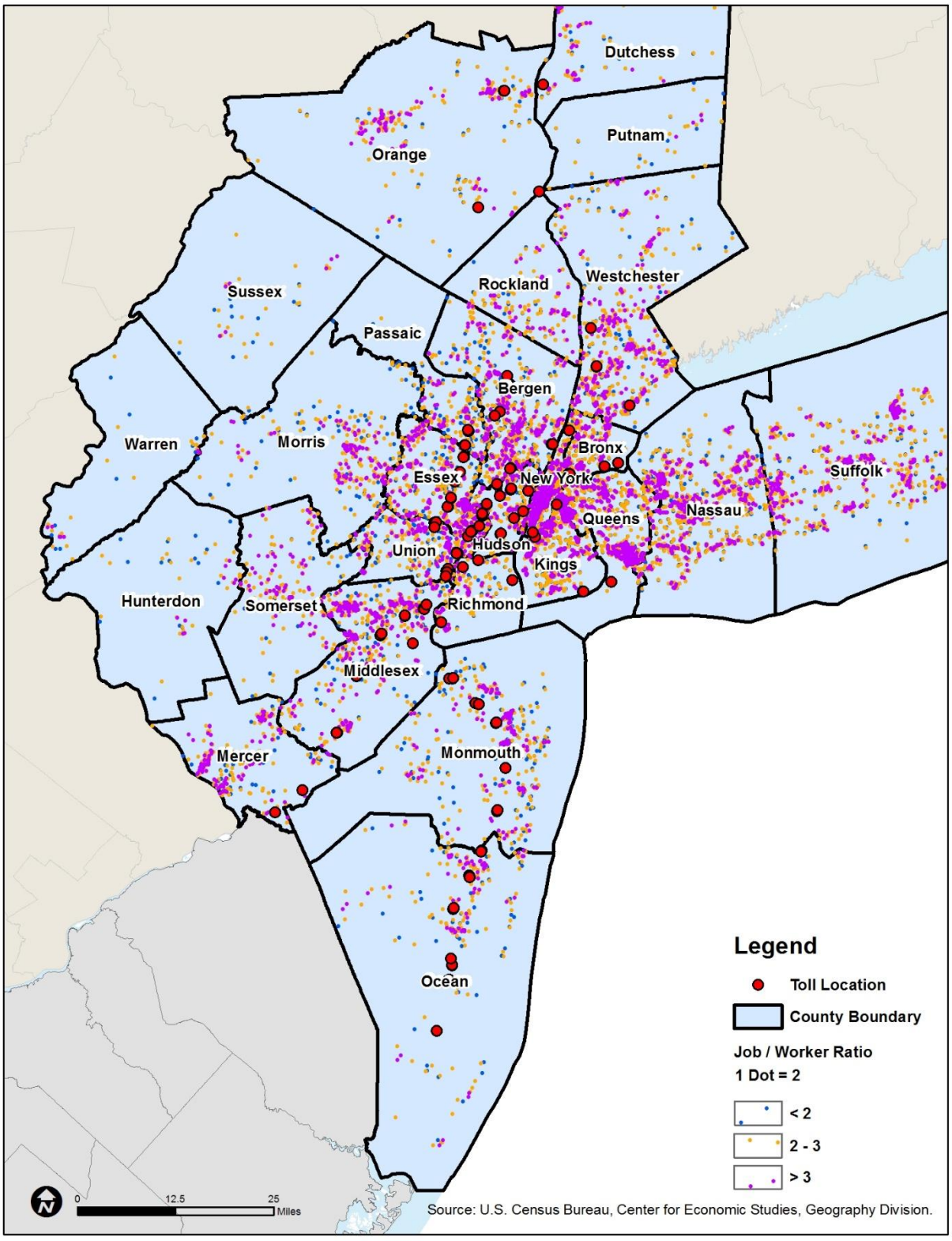


Figure 3. Jobs-Workers Ratios in Relation to Toll Locations in the New York Metropolitan Area

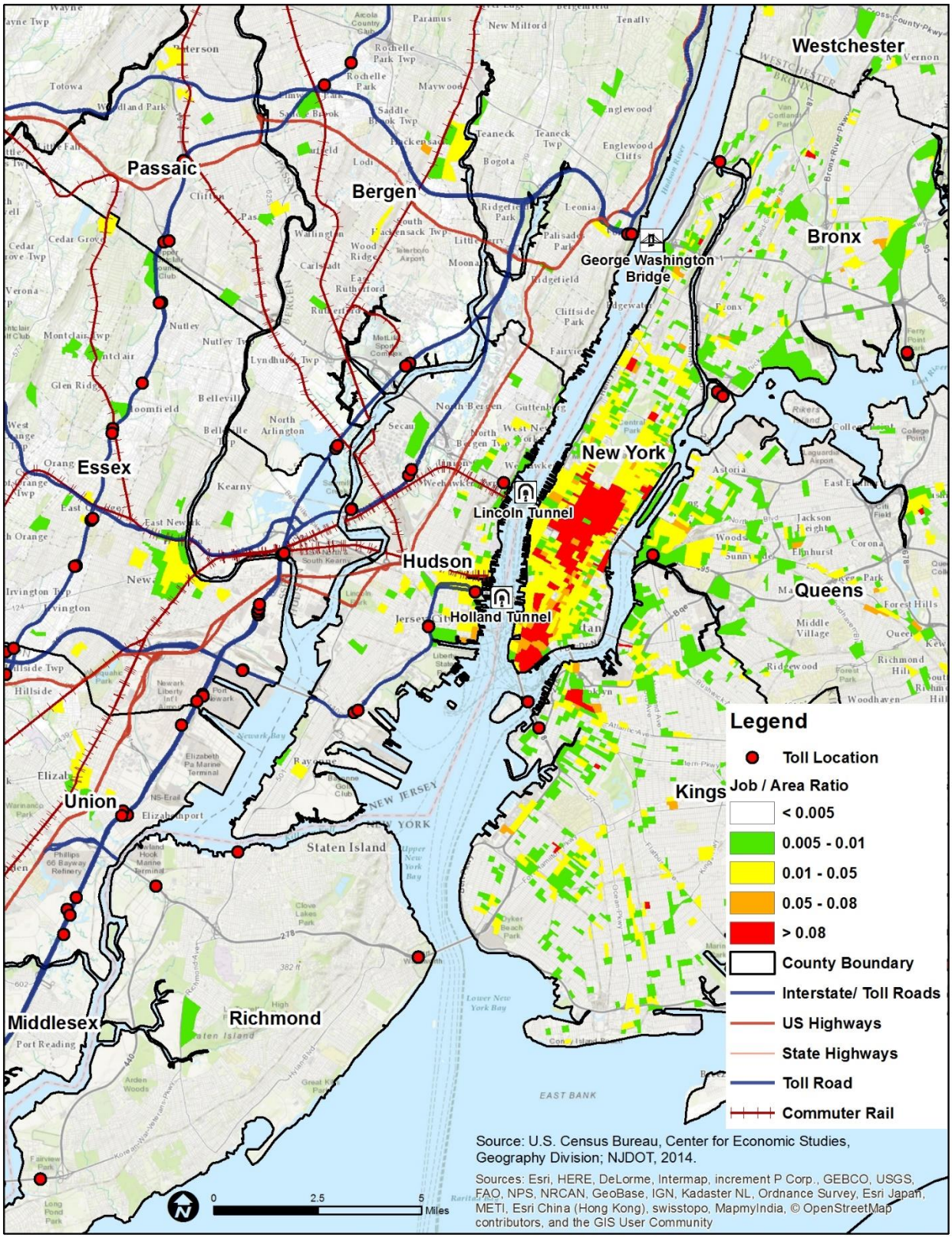


Figure 4. Job Density in Relation to Toll Locations in Central New York Metropolitan Area

## 2. APPROACH

This research bridges the gap in existing literature by comparing the characteristics of people who use toll facilities with those who use alternative roads and public transportation. Instead of examining through hypothetical scenarios whether low-income and minority populations are supportive of tolls, it examines through actual trip-making behavior whether people belonging to different socioeconomic groups have similar propensities to use toll facilities, alternate routes, and alternate public transportation modes. It hypothesizes that low-income and minority population are less likely to use toll facilities, whereas high-income and non-minority populations are more likely to use toll facilities and less likely to use alternate routes because of their greater emphasis on saving travel time. In addition to comparing the characteristics of toll payers with alternative route and mode users, this research investigates the effects of travel subsidization by employers, such as toll and transit fare incentives.

Figure 5 can help to understand the research concept. Thousands of trips take place on a day in a metropolitan area, but only a small proportion would encounter toll facilities on the fastest route between the trip origin and trip destination. While some travelers encountering toll facilities pay a fee to use the facilities, others use alternative routes (often spending longer time) or alternative transit modes such as trains and buses. This research compares the characteristics of the toll payers, the alternative route users, and public transportation users by focusing on only those trips that would encounter a toll on the fastest route. The exclusive focus on only those trips is important for the hypothesis that the alternative route and mode users seek to avoid toll facilities.

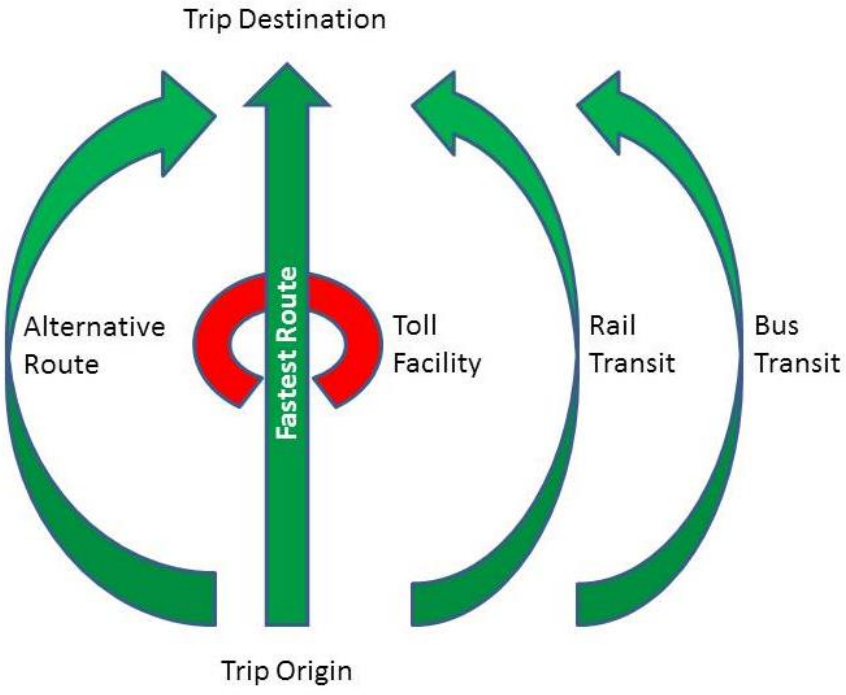


Figure 5. The concept of Comparing Toll Users with Alternative Route and Mode Users

In order to answer the research questions, this study takes recourse to statistical models. Separate analyses are carried out to examine the propensity of using toll facilities

(versus alternate routes and public transit modes) by the general population and workers. While the analyses pertaining to the general population are pertinent to the federal government's emphasis on environmental justice, the analyses regarding workers are pertinent to the Ladders of Opportunity initiative of the US Department of Transportation.

## 3. METHODOLOGY

### 3.1. Data

The primary data source for this research is the 2010-11 household survey conducted by New York Metropolitan Transportation Council (NYMTC) and the North Jersey Transportation Planning Authority (NJTPA). The survey collected data on travel and personal characteristics from residents in the area shown in Figure 1, which encompasses 14 counties in New Jersey, 12 counties in New York State, and two counties in Connecticut. The survey data includes three components: the household dataset, the person dataset, and the trip dataset. The trip dataset from the survey contained information for 188,199 trips made by 43,558 persons from 18,965 households in the entire study area. The survey data indicates whether tolls were paid for a trip and how the tolls were paid (i.e., cash or E-ZPass). Although the survey data can be directly used to compare the differences between persons who paid tolls with other travelers, comparing toll payers with all other travelers does not necessarily provide useful insights since most trips in the region do not encounter toll facilities either because they are local in nature or there are no toll facilities within the daily travel shades of the travelers.

In order to identify trips that would require travelers to use toll facilities if they wanted to travel between the origin and destination by the fastest route, it was necessary to use the ArcGIS Network Analyst with a GIS road network for the study area. The GIS dataset, containing information on all major roads within the study region, their functional classes, and the location of tolls, was obtained from NYMTC. The dataset was converted to a network where the trips from the survey could be assigned by the ArcGIS Network Analyst. The functional classes of the roads were used to assign a speed to each link or network segment.

Instead of the actual addresses, the survey data included the census tract codes (Federal Information Processing Standard codes) and traffic analysis zone (TAZ) numbers of the origins and destinations. Since there were more TAZs than census tracts in the New Jersey part of the region, for greater precision, TAZ centroids were used as the origins and destinations in New Jersey. Since there were more tracts than TAZs in New York and Connecticut, tract centroids were used for origins and destinations in those two states. Trips were thus assigned between centroids of tracts or TAZs, depending on whether the trip origins and destinations were in New Jersey or the other two states. After assigning the trips, the estimated travel time between the origins and destinations was compared with Google Maps for a large number of trips to ensure that the estimates were reasonably accurate. Although the use of TAZ and tract centroids potentially resulted in somewhat imprecise estimates of travel time compared to what might have been estimated from the use of actual addresses, considering that most trips having a toll facility between the origins and destinations are long-distance trips, the measurement errors can be considered to be negligible.

From the trip assignment effort, it was determined that 10,096 of the trips (5.4% of total) would encounter at least one toll facility if they were made by automobile using the fastest route

between the origins and destinations. The survey data revealed that a portion of those trips was made by using toll facilities, another portion was made by automobile on slower routes, yet another portion was made by fixed-route transit modes, and a very small portion was made by other modes such as school buses and taxis. For the analysis in the following section, only those trips were used that would encounter a toll facility on the fastest automobile route and were made by single occupancy vehicles (SOV), high occupancy vehicles (HOV), rail transit, and bus transit. Although the survey data includes PATH/Subway as another mode, in reality, the PATH system and the subway system have significantly different characteristics. Due to the difficulty in separating PATH trips from Subway trips, the modeling effort in the following section excludes the PATH/Subway mode.

### 3.2. Statistical Methods

Chi-square tests and binary logit models were used to compare toll payers with alternative route and mode users. Comparisons were made regarding demographic and socioeconomic characteristics.

Results from the binary logit models are presented in the following sections from two separate sets of analysis. The first set of analysis pertains to all travelers, whereas the second set pertains to workers only. The model results pertaining to all travelers are presented in Section 4.1. The model results pertaining to workers are presented in Section 4.2. In both sets of models, only those trips were analyzed that would encounter toll facilities if they were made by highways. Trips made within areas that have no toll facilities (e.g., trips within Morris County or trips from Morris County to Sussex County) were excluded since they are not pertinent to this research.

## 4. FINDINGS

### 4.1. Analyses of Trips for All Purposes

The data analyses and their results are presented below in three subsections. The first subsection presents results from a basic comparison of the characteristics of toll payers and others to show that all travelers are not equally likely to use toll facilities. The second subsection provides results from three binary logit models comparing the characteristics of toll payers with alternative route users, bus users, and rail users. The third subsection provides results from two additional logit models comparing alternative route users with bus users and rail users to provide greater insights about their differences.

#### 4.1.1. Basic Comparison of Toll Payers with Alternative Route and Mode Users

The survey data revealed 5.2% of the study area population paid tolls on the day of the survey. A comparison of the characteristics of the toll payers with the characteristics of the rest of the general population showed that a significantly greater proportion of men (6.5%), persons in age 35 to 54 (8.2%), persons from households with income over $150,000 (8.4%), white persons (6.2%), full time workers (9.7%), and New Jersey residents (8.3%) paid tolls on the travel day compared to others. If these population groups were as likely to pay toll as others, only 5.2% of each group would have paid toll. In contrast, significantly smaller proportions of persons from households with less than $30,000 annual income (1.7%), African American

persons (3.4%), Hispanic persons (3.5%) and persons with disabilities (2.3%) paid toll on the travel day.

Although a comparison of toll payers with the general population is informative in a broad sense, it is more meaningful to compare toll payers with travelers who avoid paying tolls by using alternative routes or modes since the rest of the people's daily travel sheds may not include any toll facility. Table 1 shows such a comparison of toll payers with aggregated alternative route and mode users. The first row of the table shows that 36.4% of trips by men involved toll payment, meaning that the remaining 63.6% trips avoided toll facilities by using alternative routes or modes. In contrast, 27.9% of the trips by women involved toll payment and the remaining 72.1% tips used alternative routes or modes. Thus men are more likely to use toll facilities than women. Other results in the table can be interpreted similarly.

The comparisons of traveler characteristics in Table 1 were made after converting the variables to binary form since many of them are used as dummy variables in the following section. For the ease of comprehending the magnitude of the differences, the ratios of the percentages are also presented in the table. A larger deviation of the ratio from 1 in either direction indicates a larger difference between the percentages for the two categories.

Table 1 clearly shows that greater proportions of male travelers, middle-aged travelers, high-income travelers, white travelers, English-speaking travelers, working travelers, and travelers residing in New Jersey, pay tolls than the groups they are compared with. In contrast, very young travelers, African American travelers, travelers from low-income households, and persons with disabilities are less likely to pay tolls. These findings helped to develop the hypotheses for the modeling effort in the following sections.

**Table 1. Percent of Trips for which Travelers Paid Toll when One or More Toll Facilities were Located on the Fastest Route between Origins and Destinations**

| Personal Characteristics | Percent Paid Toll | Ratio of the Percentages |
|---|---|---|
| Male | 36.4% | 1.30 |
| Female | 27.9% | |
| Age 18 or lower | 15.9% | 0.47 |
| Not age 18 or lower | 33.8% | |
| Age 19-34 | 27.2% | 0.80 |
| Not age 19-34 | 34.0% | |
| Age 35-54 | 34.1% | 1.09 |
| Not age 35-54 | 31.4% | |
| Age 55 to 64 | 38.8% | 1.24 |
| Not age 55 to 64 | 31.2% | |
| Age 65 or over | 36.6% | 1.14 |
| Not age 65 or over | 32.2% | |
| Household Income below $30k | 19.7% | 0.57 |
| Income not below $30k | 34.7% | |
| Household income $30k-$74.9k | 32.3% | 0.97 |
| Income not below $30k-$74.9k | 33.2% | |
| Household income $75k-$99.9k | 29.7% | 0.89 |
| Income not $75k-$99.9k | 33.4% | |
| Household income $100k-$149.9k | 36.5% | 1.14 |
| Income not $100k-$149.9k | 32.0% | |
| Household income $150k or over | 39.2% | 1.26 |
| Income not $150k or over | 31.0% | |
| African American | 29.9% | 0.91 |
| Not African American | 32.9% | |
| White | 37.2% | 1.64 |
| Nonwhite | 22.7% | |
| Hispanic | 22.0% | 0.64 |
| Not Hispanic | 34.2% | |
| English speaker | 33.2% | 1.34 |
| Not English speaker | 24.8% | |
| Person with disability | 24.5% | 0.75 |
| Not person with disability | 32.7% | |
| Full time worker | 35.1% | 1.25 |
| Not full time worker | 28.0% | |
| Full or part time worker | 34.2% | 1.33 |
| Not full or part time worker | 25.8% | |
| Retired person | 32.1% | 0.99 |
| Not retired person | 32.5% | |
| New York City resident (five boroughs) | 23.2% | 0.60 |
| Not New York City resident | 38.4% | |
| New Jersey resident | 40.7% | 1.51 |
| Not New Jersey resident | 26.9% | |
| Connecticut resident | 21.7% | 0.67 |
| Not Connecticut resident | 32.6% | |

Percentages are weighted percentages.
All differences are significant at 5% level on chi-square test.

### 4.1.2. Models Comparing Alternative Route and Mode Users with Toll Payers

For an in-depth examination of the differences between toll payers and others observed in Table 1, three binary logit models were run to compare the characteristics of the toll payers with the characteristics of the alternative route and mode users. An advantage of these models over the basic single-variable comparisons in Table 1 is that they control for variations in the other variables when making comparisons.

Table 2 shows the results from the logit model comparing toll payers with alternative route users. In this model, the dependent variable was coded 1 for toll payers and 0 for those who took alternative routes. The table shows the odds ratios, expressed as Exp(B), and the 95% confidence intervals of the odds ratios for the independent variables.

In addition to several variables in Table 1, a few additional variables were included in the model due to their relevance to the research question at hand. They are, a continuous variable on number of vehicles in household, a dummy variable indicating whether the trip was to or from work, a dummy variable indicating if the traveler received a transit benefit from the employer, a dummy variable indicating if the traveler received parking benefit from the employer, and a dummy variable indicating if the traveler received any toll or E-ZPass benefit from the employer. Among the variables in Table 1, the variables on retired person, African American person, English speaker, and worker status were not included in the model due to their high correlation with other independent variables.

Several important observations can be made from the results in Table 2. First, the variable on number of vehicles in household does not affect whether a traveler uses toll facilities or alternate routes. Second, travelers are approximately 29% less likely to use alternate routes for work trips and 73% less likely to use alternate routes if they receive toll or E-ZPass benefits from the employer. However, receiving parking or transit benefits does not have a significant effect on the selection of alternate routes. Third, male travelers are 29% less likely and nonwhite travelers 35% more likely to use alternate routes compared to others. Fourth, travelers in age 35-54 are significantly less likely to use alternate routes and more likely to use toll facilities compared to persons below age 35. Fifth, travelers with annual household income less than $30,000 are twice as likely to use alternate routes as travelers with income over $150,000 and 56% more likely to use alternate routes than travelers with income between $30,000 and $75,000. The dummy variables on income categories together show that the propensity to use alternate routes decreases with increases in income, meaning that the likelihood of using toll facilities increases with income. Thus high-income persons are more likely to use toll facilities than low-income persons. Finally, New Jersey residents are more likely to use alternate routes, potentially because tolls are more ubiquitous there than in the other two states. Several variables included in the model are not statistically significant, the most notable being the variable indicating Hispanic status of travelers.

The results of the model comparing bus users with toll payers are shown in the first three columns of Table 3, whereas the results of the model comparing rail users with toll payers are shown in the three columns on the right side of the table. The results of the model comparing bus users are discussed first, followed by the results of the model comparing rail users.

**Table 2. Binary Logit Model Comparing Alternative Route Users (Coded 1) with Toll Payers (Coded 0) – All Trips**

| Variables | Exp(B) | 95% CI Lower Bound | 95% CI Upper Bound |
|---|---|---|---|
| Constant | -0.505** | NA | NA |
| Number of vehicles in household | 1.002 | 0.941 | 1.068 |
| Trip to or from work | 0.705** | 0.622 | 0.799 |
| Receives transit benefit from employer | 0.963 | 0.599 | 1.547 |
| Receives parking benefit from employer | 0.826 | 0.681 | 1.003 |
| Receives toll/E-ZPass benefit from employer | 0.265** | 0.187 | 0.377 |
| Male | 0.708** | 0.628 | 0.798 |
| Nonwhite | 1.354*** | 1.155 | 1.587 |
| Hispanic | 1.139 | 0.916 | 1.415 |
| Age below 35 (Referent) | | | |
| Age 35 to 54 | 0.789** | 0.672 | 0.926 |
| Age 55 to 64 | 0.809** | 0.680 | 0.962 |
| Age 65 or over | 0.939 | 0.745 | 1.183 |
| Household income below $30k | 2.017** | 1.547 | 2.630 |
| Household income between $30k-$74.9k | 1.455** | 1.225 | 1.729 |
| Household income between $$75k-$99.9k | 1.534** | 1.263 | 1.862 |
| Household income between $100k-$149.9k | 1.348** | 1.131 | 1.607 |
| Household income $150k or over (Referent) | | | |
| Person with disability | 0.971 | 0.680 | 1.387 |
| New Jersey resident | 1.538** | 1.354 | 1.746 |
| Connecticut resident | 1.447 | 0.660 | 3.176 |
| New York State resident (Referent) | | | |
| | | | |
| Toll payers | 2999 | | |
| Alternate route users | 1944 | | |
| Overall correct prediction | 63.4% | | |
| -2 Log likelihood | 6297 | | |

CI = Confidence Interval
NA = Not applicable
** Significant at 1% level

In contrast to the model in Table 2, the bus user model in Table 3 shows a negative association between number of vehicles in household and bus use, indicating that persons with no or few vehicles in households are more likely to use buses than persons with more vehicles in household. The model shows an even smaller likelihood of using buses for work trips than using alternate routes in the first model, meaning that buses are not frequently used as an alternative for work trips. Among all the variables included in the model, receiving transit benefits from employer has the greatest positive effect on selecting buses over toll facilities. However, receiving parking and E-ZPass/toll benefits from employers significantly reduces the likelihood of using buses and increases the likelihood of using toll facilities. While gender has no effect on using buses, nonwhite persons are more likely to use buses than white persons.

**Table 3. Binary Logit Model Comparing Bus Users (Coded 1) and Rail Users (Coded 1) with Toll Payers (Coded 0) – All Trips**

| | Model Comparing Bus Users | | | Model Comparing Rail Users | | |
|---|---|---|---|---|---|---|
| Variables | Exp(B) | 95% CI Lower Bound | 95% CI Upper Bound | Exp(B) | 95% CI Lower Bound | 95% CI Upper Bound |
| Constant | 1.382** | NA | NA | 1.402** | NA | NA |
| Number of vehicles in household | 0.387** | 0.340 | 0.440 | 0.732** | 0.664 | 0.806 |
| Trip to or from work | 0.028** | 0.019 | 0.042 | 0.018** | 0.012 | 0.026 |
| Receives transit benefit from employer | 15.677** | 10.110 | 24.309 | 16.433** | 10.723 | 25.184 |
| Receives parking benefit from employer | 0.268** | 0.165 | 0.437 | 0.294** | 0.200 | 0.432 |
| Receives toll/E-ZPass benefit from employer | 0.127** | 0.064 | 0.255 | 0.303** | 0.198 | 0.463 |
| Male | 0.906 | 0.749 | 1.097 | 1.322** | 1.108 | 1.578 |
| Nonwhite | 1.705** | 1.358 | 2.140 | 0.893 | 0.701 | 1.138 |
| Hispanic | 1.452* | 1.069 | 1.972 | 0.771 | 0.545 | 1.090 |
| Age below 35 (Referent) | | | | | | |
| Age 35 to 54 | 1.082 | 0.839 | 1.395 | 1.192 | 0.945 | 1.504 |
| Age 55 to 64 | 0.599** | 0.454 | 0.790 | 0.675** | 0.524 | 0.868 |
| Age 65 or over | 0.428** | 0.292 | 0.627 | 0.290** | 0.196 | 0.430 |
| Household income below $30k | 0.573** | 0.389 | 0.845 | 0.302** | 0.203 | 0.452 |
| Household income between $30k-$74.9k | 0.451** | 0.337 | 0.604 | 0.307** | 0.238 | 0.395 |
| Household income between $$75k-$99.9k | 0.969 | 0.706 | 1.329 | 0.550** | 0.417 | 0.726 |
| Household income between $100k-$149.9k | 0.896 | 0.678 | 1.183 | 0.684** | 0.546 | 0.856 |
| Household income $150k or over (Referent) | | | | | | |
| Person with disability | 0.612 | 0.358 | 1.047 | 0.259** | 0.120 | 0.557 |
| New Jersey resident | 1.171 | 0.965 | 1.422 | 0.350** | 0.294 | 0.418 |
| Connecticut resident | 0.227 | 0.026 | 1.958 | 2.814** | 1.375 | 5.758 |
| New York State resident (Referent) | | | | | | |
| | | | | | | |
| Toll payers | 2999 | | | 2999 | | |
| Bus (first model) or rail (second model) users | 918 | | | 1308 | | |
| Overall correct prediction | 84.9% | | | 81.10% | | |
| -2 Log likelihood | 2661 | | | 3210 | | |

CI = Confidence Interval
NA = Not applicable
** Significant at 1% level
* Significant at 5% level

The variable on Hispanic status in Table 3 is significant and positive, but the wide range between the lower and upper bounds of the confidence interval indicates a substantial variation among Hispanic travelers. The variables on age indicate that persons over 55 are less likely to select buses over toll facilities. In contrast to the model in Table 2, this model shows that travelers with less than $30,000 annual income, as well as travelers with income in the $30,000-$75,000 range, are less likely to use buses. Since low-income persons are usually more likely to use buses than high-income persons, a potential reason for this finding could be that buses do not serve as an acceptable alternative for low-income travelers when one considers only those

services that compete with toll facilities, such as the Trans-Hudson bus services connecting New Jersey and New York City.

The results of the model on rail users in the right hand side of Table 2 are somewhat similar to the bus user model on the left side, but not all variables show similar results. The variables on number of vehicles, work trip, and employer benefits show similar results, but in contrast to the bus user model, the rail user model shows that men are more likely to use rail and race has no effect on using rail. Similar to the bus user model, the rail user model also shows a lower likelihood of using rail by travelers age 55 and over. The model shows that travelers with less than $30,000 annual household income are even less likely to use rail than buses when the other alternative is to use toll facilities. The income variables together show that the likelihood of using rail increases with income and the likelihood is the highest for persons with income over $150,000. In contrast to the model on bus users, the rail user model shows a lower likelihood of using rail by persons with disabilities and New Jersey residents and a higher likelihood of using rail by Connecticut residents.

### 4.1.3. Models Comparing Alternative Route Users with Bus and Rail Users

As discussed in the literature review, public transit enhancement and transit subsidy are often recommended to address potential disparities associated with tolling. However, the models presented in Tables 2 and 3 indirectly show that the characteristic of those who use alternate routes instead of toll facilities are not necessarily the same as those using buses and rail. To gain deeper insights about the differences between alternate route users and transit users, an effort has been made here to directly compare alternate route users, rail users, and bus users by using two binary logit models. The dataset used for the two models is the same as that used for the models in Tables 2 and 3, meaning that it is restricted to trips that had at least one toll facility on the fastest route between the trip origins and destinations.

The results of the model comparing alternate route users with bus users are shown in the first three columns of Table 4, whereas the results of the model comparing alternate route users with rail users are presented in the three columns on the right hand side. In both models, alternate route users are coded 1 and the transit users are coded 0. The variables included in the models are the same as those included in the previous models.

The model comparing alternate route users with bus users show that the likelihood of selecting alternate route over buses is higher when there are more vehicles in households, trips are made to or from work, and travelers receive parking benefits from employers. Nonwhite travelers are less likely and travelers in age groups 35-54 and 65 and over are more likely to select alternate routes over buses. In contrast to nonwhite travelers, who are more likely to select buses over alternate routes, travelers with income less than $30,000 are more likely to select alternate routes over buses. This result may indicate that for low-income travelers, the existing bus services competing with toll facilities may not provide a viable travel alternative. Finally, the model also shows a greater likelihood of using alternate routes instead of buses by persons with disabilities and New Jersey residents.

**Table 4. Binary Logit Model Comparing Alternative Route Users (Coded 1) with Bus Users (Coded 0) and Rail Users (Coded 0) – All Trips**

| | Model Comparing Bus Users | | | Model Comparing Rail Users | | |
|---|---|---|---|---|---|---|
| Variables | Exp(B) | 95% CI Lower Bound | 95% CI Upper Bound | Exp(B) | 95% CI Lower Bound | 95% CI Upper Bound |
| Constant | -1.516** | NA | NA | -1.537** | NA | NA |
| Number of vehicles in household | 2.368** | 2.081 | 2.694 | 1.281** | 1.151 | 1.427 |
| Trip to or from work | 23.532** | 15.441 | 35.863 | 40.892** | 26.568 | 62.939 |
| Receives transit benefit from employer | 0.071** | 0.043 | 0.117 | 0.053** | 0.032 | 0.087 |
| Receives parking benefit from employer | 2.476** | 1.439 | 4.260 | 2.327** | 1.486 | 3.645 |
| Receives toll/E-ZPass benefit from employer | 1.235 | 0.489 | 3.116 | 0.766 | 0.399 | 1.470 |
| Male | 0.866 | 0.713 | 1.051 | 0.572** | 0.471 | 0.694 |
| Nonwhite | 0.784* | 0.622 | 0.988 | 1.604** | 1.235 | 2.083 |
| Hispanic | 0.762 | 0.562 | 1.032 | 1.269 | 0.875 | 1.841 |
| Age below 35 (Referent) | | | | | | |
| Age 35 to 54 | 0.638** | 0.498 | 0.817 | 0.583** | 0.457 | 0.743 |
| Age 55 to 64 | 1.030 | 0.781 | 1.359 | 0.930 | 0.707 | 1.222 |
| Age 65 or over | 2.310** | 1.590 | 3.356 | 3.551** | 2.350 | 5.365 |
| Household income below $30k | 2.817** | 1.900 | 4.178 | 3.976** | 2.606 | 6.065 |
| Household income between $30k-$74.9k | 2.722** | 2.009 | 3.689 | 3.318** | 2.511 | 4.385 |
| Household income between $$75k-$99.9k | 1.479* | 1.061 | 2.062 | 2.472** | 1.806 | 3.383 |
| Household income between $100k-$149.9k | 1.190 | 0.888 | 1.596 | 1.496** | 1.154 | 1.940 |
| Household income $150k or over (Referent) | | | | | | |
| Person with disability | 2.215** | 1.306 | 3.756 | 5.272** | 2.426 | 11.458 |
| New Jersey resident | 1.380** | 1.124 | 1.694 | 5.032** | 4.127 | 6.136 |
| Connecticut resident | 3.439 | 0.362 | 32.661 | 0.435 | 0.183 | 1.032 |
| New York State resident (Referent) | | | | | | |
| | | | | | | |
| Alternative route users | 1944 | | | 1944 | | |
| Bus (first model) or rail (second model) users | 918 | | | 1308 | | |
| Overall correct prediction | 78.9% | | | 81.1% | | |
| -2 Log likelihood | 2503 | | | 2618 | | |

CI = Confidence Interval
NA = Not applicable
** Significant at 1% level
* Significant at 5% level

The results of the model comparing alternate route users with rail users are mostly similar to the model comparing bus users on the left hand side of the table, but they are different in a few regards. First, men are less likely to use alternate routes when the comparison is made with rail users, meaning their propensity to use rail is higher. Second, nonwhite travelers are more likely to use alternate route instead of rail. This result may indicate that rail may be a less viable alternative for nonwhite travelers than white travelers. Finally, similar to the model comparing bus users in the left hand side, the model comparing rail users shows that travelers with less than $30,000 annual income are more likely to select alternate route over rail. A

comparison of the odds ratios (3.98 for rail against 2.82 for bus) shows that rail is even less attractive to such travelers than buses. In sum, compared to driving on alternate routes, buses appear to be a more viable alternative for nonwhite travelers than white travelers, rail appears to be a more viable alternative for white travelers than nonwhite travelers, and both bus and rail appear to be less viable alternatives for low-income travelers than high income travelers.

### 4.2. Analyses of Trips to or from Work

The model results in Tables 2 through 4 were obtained by analyzing tips for all purposes by the population as a whole. Although informative and insightful, the analyses were not made exclusively for work trips. Since work trips are non-discretionary and tolls are likely to affect work trips more than trips for other purposes (e.g., shopping or social/recreational trips that are made less frequently), a separate set of analysis was conducted by restricting the data to work trips only.

An attempt was made to replicate all models in Tables 2, 3, and 4 by restricting the dataset to work trips only. However, it was discovered that the survey data are too limited for bus trips and rail trips when only work trips are used for modeling purposes. Since the results of the models comparing bus and rail users with toll payers and alternative route users are unreliable because of small samples, only the results from a model comparing toll payers with alternative route users are presented in Table 5. As shown at the bottom of the table, data for 1523 toll-paying trips and 747 trips using alternative routes were used for the model.

The model results in Table 5 for work trips are generally consistent with the results from the all-purpose trips for the general population in Table 2. Like the model in Table 2, the model in Table 5 also shows that nonwhite workers and low-income workers are more likely to use alternate routes compared to others. Although the odds ratio for nonwhite workers in Table 5 is very similar to the odds ratio for nonwhite persons in Table 2 (1.354 versus 1.321), the odds ratio for low-income workers is substantially larger than the odds ratio for low-income persons (2.017 versus 3.232). Thus the effect of tolls on low-income workers may be greater than low-income persons in general.

Other model results in Table 5 are also consistent with the results in Table 2. For example, the model for work trips in Table 5 also show that workers with larger number of vehicles in household, male workers, and workers receiving toll/E-ZPass benefits from employers are less likely to use alternate routes and more likely to use toll facilities. However, in one regard the model results in Table 5 are inconsistent with the results in Table 2. While the variable on New Jersey residence was significant in the model in Table 2, the variable is not significant in the model in Table 5.

## 5. CONCLUSIONS

By using household travel survey data, this research compared the personal characteristics of travelers who use toll facilities with travelers who use alternative routes and modes by taking the greater New York metropolitan area as a case study. In view of findings in other studies, it examined whether persons from low-income and minority households are less likely to use toll facilities at the metropolitan area level. The basic comparisons in Tables 1 and the binary logit model in Tables 2 showed that low-income and nonwhite travelers are more likely to use alternative routes instead of toll facilities. On the whole, the results are consistent

with empirical studies on actual toll-paying behavior reviewed by Plotnick et al. (2011), but contrary to inferences in certain stated preference studies (Halvorson and Buckeye 2006; Ungemah et al. 2005).

**Table 5. Binary Logit Model Comparing Alternative Route Users (Coded 1) with Toll Payers (Coded 0) – Work Trips Only**

| Variables | Exp(B) | 95% CI Lower Bound | 95% CI Upper Bound |
|---|---|---|---|
| Constant | 0.242** | NA | NA |
| Number of vehicles in household | 1.103* | 1.006 | 1.210 |
| Receives transit benefit from employer | 0.982 | 0.523 | 1.847 |
| Receives parking benefit from employer | 1.031 | 0.806 | 1.318 |
| Receives toll/EZPass benefit from employer | 0.283** | 0.176 | 0.455 |
| Male | 0.700** | 0.582 | 0.843 |
| Nonwhite | 1.321* | 1.039 | 1.680 |
| Hispanic | 1.168 | 0.848 | 1.609 |
| Age below 35 (Referent) | | | |
| Age 35 to 54 | 1.036 | 0.798 | 1.346 |
| Age 55 to 64 | 1.321 | 0.989 | 1.765 |
| Age 65 or over | 1.004 | 0.580 | 1.737 |
| Household income below $30k | 3.232** | 2.007 | 5.206 |
| Household income between $30k-$74.9k | 1.904** | 1.457 | 2.486 |
| Household income between $$75k-$99.9k | 2.029** | 1.523 | 2.702 |
| Household income between $100k-$149.9k | 1.814** | 1.400 | 2.349 |
| Household income $150k or over (Referent) | | | |
| Person with disability | 0.468 | 0.183 | 1.196 |
| New Jersey resident | 1.178 | 0.971 | 1.430 |
| Connecticut resident | 1.517 | 0.478 | 4.809 |
| New York State resident (Referent) | | | |
| | | | |
| Toll payers | 1523 | | |
| Alternate route users | 747 | | |
| Overall correct prediction | 67.6% | | |
| -2 Log likelihood | 2759 | | |

CI = Confidence Interval

NA = Not applicable

** Significant at 1% level

* Significant at 5% level

The model comparing bus users with toll payers in Table 3 showed that nonwhite travelers have higher, but low-income travelers have lower propensity to select buses over toll facilities, whereas the model comparing rail users with toll payers in the same table showed that low-income travelers have a lower propensity to select rail but race has no effect on rail use. Although public transit is often recommended as an alternative for low-income populations adversely affected by tolls, these results do not indicate that existing bus and rail systems in the study area serve as viable alternatives for low-income travelers when tolls are present between their trip origins and destinations. These results were further substantiated when alternate route users were compared with bus and rail users in Table 4, where it was clearly observed that low-income travelers have a higher likelihood of using alternate routes over buses and trains. Nonwhite travelers also have a higher likelihood of using alternate routes over trains, but they have a higher likelihood of using buses over alternate routes.

The results of the model comparing toll users and alternate route users with work trips only, shown in Table 5, were consistent with the results of the model with all trips, shown in Table 2. The model results in Table 5 indicated that even for work trips, low-income and minority populations may be affected to a greater degree by tolls than non-minority and high-income populations.

The empirical findings of this research have significant implications for planning and public policy. Based on the model results, one can suggest that re-aligning transit services on routes competing with toll facilities to serve low-income and minority populations will increase their propensity to use buses and trains and help to avoid tolls. Based on the study's finding that employer-based transit benefits raise the propensity to use transit, one can suggest that subsidized transit fare for low-income riders on routes that are alternative to toll facilities could have a similar effect. Since employer-based toll benefits and parking benefits reduce travelers' likelihood of using buses and trains, discouraging such benefit programs may benefit transit by diverting travelers from toll facilities to transit. That, in turn, may allow transit agencies to keep fares lower, which would benefit low-income travelers. Means-tested strategies, such as giving a quota of free transit trips to persons from low-income households, may also benefit those affected by tolls.

Transit enhancements such as the addition of bus routes on toll roads could be beneficial since they would allow travelers to use buses instead of driving and paying tolls. Organized carpools and vanpools between large activity centers separated by toll facilities, especially bridges with high toll rates, could also be beneficial. Considering that a large number of jitneys in the region allow many persons from minority and low-income communities to travel through high-rate toll facilities like the trans-Hudson bridges and tunnels without having to pay any toll, integration of such services with formal public transportation could further benefit low-income and minority populations.

The study findings also have land use implications. Since tolls are imposed primarily on major highways and bridges that are often used for long distance travel, any policy that could reduce the need for long-distance travel would benefit all, including low-income and minority travelers. Policies such as jobs-housing balance and mixed-use development could be particularly beneficial since they can potentially reduce the need for long-distance travel.

## 6. RECOMMENDATIONS

Two types of recommendations can be made from this research, namely, policy recommendations and research recommendations. The foremost policy recommendation would be to add and improve public transportation between significant origins and destinations separated by tolls so that low-income and minority populations can travel by paying a modest fare and arrive at destinations at a reasonable time. Transit improvements should be more intense when it is virtually impossible to travel between trip origins and destinations by alternate routes, as in the case of the trans-Hudson travel. Since transit trips usually take significantly longer time than automobile trips, improving transit frequency would be beneficial. Subsidized transit fare would also help low-income persons to avoid paying tolls. When conventional transit does not exist, informal services like jitneys would also help because of their low fares and popularity among minority populations.

The differences in conclusions of studies that examine people's preference for tolls under hypothetical conditions and actual toll-paying studies indicate that the hypothetical studies should collect data from only those people who would be definitely affected by tolls instead of collecting data from the general population. Those studies should also ensure that the persons providing survey responses know precisely what they would encounter when toll projects are completed. In regards to environmental justice considerations, care is needed to define low-income persons properly. When the low-income threshold is not properly set, responses from moderate-income persons may be misinterpreted as responses from low-income persons.

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