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Attachment 4 to Attachment D:
Statistical Modeling For Urban Rail Corridors
(Data from the San Francisco Bay Area)

This Attachment describes analysis conducted using 2000 Bay Area Travel Survey (BATS) data. The 2000 BATS data was used since it represents a sample four times as large as the 2009 NHTS survey subset for the nine-county Bay region. Furthermore, the Metropolitan Transportation Commission (MTC) has enhanced the BATS data set with supplemental variables such as accessibility by auto, transit and non-motorized modes.

A variety of regression models were estimated to predict vehicle trip rates and VMT per household. Many regression models were considered, including minor variations not reported here. The best-performing models will become the analytic engines of the Urban Rail Corridor Ds Analysis Modules for estimating vehicle trips and VMT in regions with urban rail transit, as described in the main report. The regression model that is recommended as the basis of the Vehicle Trip Ds Analysis Module is described on pp. 12-13. The regression model that is recommended as the basis of the VMT Ds Analysis Module is described on page17. In addition, mode split of work and non-work trips to locations near rail transit stations was analyzed and models created to predict mode shares and trip distances for trips destined to station areas; these are described on pp. 26 – 41.

1.0 HOUSEHOLD VEHICLE TRIP RATE AND VMT DESCRIPTIVE STATISTICS

Households located further from a rail station tend to have higher vehicle trip rates and higher VMT per household than those located closer to rail stations. **Table 1** shows the average household daily vehicle driver trips and VMT by distance of household from a rail station based on BATS survey data.

Table 1: Vehicle Trip Rates and VMT vs. Distance to Rail

Household Location	HH Daily Vehicle Trips*	HH Daily VMT*
Within ½ Mile of a Rail Station	2.87 (2.7)	20.4 (25.3)
Within 1 Mile of a Rail Station	3.34 (3.0)	22.2 (26.1)
Within 2 Miles of a Rail Station	3.78 (3.2)	25.3 (27.4)
Within 5 Miles of a Rail Station	4.17 (3.3)	28.8 (29.4)
Within 10 Miles of a Rail Station	4.28 (3.3)	30.3 (30.4)
All Households	4.35 (3.3)	32.8 (33.3)

*First number is average value, second number (in parenthesis) is standard deviation

The values are lower than standard suburban generation rates such as those published by the Institute of Transportation Engineers (which suggest a rate of approximately 10 vehicle trips per *day for single-family dwelling units and 6 vehicle trips per day for multi-family dwelling units). The* difference is due to several factors:

- Lower vehicle ownership and use in the Bay Area compared to the US as a whole
- Absence of trips to a household that are not made by household members (e.g. trips by visitors to the household, mail delivery and other service calls to households
- The fact that survey respondents do not recall all trips, particular short, non-home based trips, especially those made by other household members.

2.0 HOUSEHOLD VEHICLE TRIP RATE AND VMT MODELS

This section presents the development of the preferred household vehicle trip rate and VMT models. The analysis uses data from households which participated in the 2000 Bay Area Travel Survey (BATS). Data from a total of 15,064 households were used. Only car driver trips were considered, not car passenger trips, since car driver trips are the only trips that contribute to increased VMT and emissions. Regressions were run to predict average car driver trip rate per household and average vehicle miles traveled per household. The methods tested and preferred models are presented.

2.1 Input Data

Table 2 lists the universe of variables available for the modeling analysis.

Table 2: Household Level Variable List

Variable Name	Description	Source
	Household Data	
Household Size	Number of persons in the household	BATS (2000)
Num Workers	Number of workers in the household	BATS (2000)
Household Vehicles	Number of vehicles in the household	BATS (2000)
Household Vehicles Category	0=zero cars in hh, 1=1 car in hh, 2=2 cars in hh, 3=3 cars in hh, 4=4+ cars in hh	Fehr & Peers (calculated in 2011 using 2000 MTC data)
Zero Car HH	Binary variable indicating household has zero vehicles (1=zero vehicles, 0=1 or more vehicles)	Fehr & Peers (calculated in 2011 using 2000 MTC data)
Owner	Binary variable indicating the household is owner occupied (0/1)	BATS (2000)
Low Income	Binary variable indicating the household income is less than $40,000 (0/1)	BATS (2000)
Multi Family Dwelling	Binary variable indicating the household is in a multi family dwelling unit (1=multi family dwelling unit, 0=single family dwelling unit)	Fehr & Peers (calculated in 2011 using 2000 MTC data)
	Rail Station Data	
Distance to Rail	Distance from household to nearest rail station (miles)	Fehr & Peers (calculated in 2011 using stations that existed in 2000)
ln(Distance to Rail)	Natural log of Distance to Rail	Fehr & Peers (calculated in 2011 using stations that existed in 2000)
Light Rail	Binary variable indicating that the closest rail station is light rail	Fehr & Peers
Trains per Day	Trains per day through the closest station to the household	Fehr & Peers
Station Parking	Hourly parking rate paid by long-term parkers in the TAZ where the station is located (2000 cents)	MTC (2000)

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Household Area Data		
Household Density TAZ	Household density of TAZ where household is located (households per acre)	MTC (2000)
Pop Density TAZ	Population density of TAZ where household is located (households per acre)	MTC (2000)
Employment DensityTAZ	Employment density of TAZ where household is located (employees per acre)	MTC (2000)
Retail Employment Density TAZ	Retail employment density of TAZ where household is located (employees per acre)	MTC (2000)
Urban Density TAZ (aka Activity Density)	Sum of population density and employment density	Fehr & Peers (calculated in 2011 using 2000 MTC data)
Diversity TAZ	Jobs/housing diversity indicator of TAZ where household is located	Fehr & Peers (calculated in 2011 using 2000 MTC data)
Auto Accessibility TAZ	Accessibility by auto during peak conditions to all employment for the TAZ where the household is located	MTC (2000)
Transit Accessibility TAZ	Accessibility by transit during peak conditions to all employment for the TAZ where the household is located	MTC (2000)
NMT Accessibility TAZ	Accessibility by NMT during all time periods to all employment for the TAZ where the household is located	MTC (2000)
HH Density HMi	Household density within ½ mile of the household (households per acre)	Fehr & Peers (calculated in 2011 using 2000 MTC data)
Pop Density HMi	Population density within ½ mile of the household (population per acre)	Fehr & Peers (calculated in 2011 using 2000 MTC data)
Emp Density HMi	Employment density within ½ mile of the household (employees per acre)	Fehr & Peers (calculated in 2011 using 2000 MTC data)
Ret Emp Density HMi	Retail employment density within ½ mile of the household (retail employees per acre)	Fehr & Peers (calculated in 2011 using 2000 MTC data)
Activity Density HMi	Sum of population density and employment density within ½ mile of the household	Fehr & Peers (calculated in 2011 using 2000 MTC data)
Diversity HMi	Jobs/housing diversity within ½ mile of where the household is located	Fehr & Peers (calculated in 2011 using 2000 MTC data)
Auto Access (HMi)	Accessibility by auto during peak conditions from the area within ½ mile of where the household is located to all employment	Fehr & Peers (calculated in 2011 using 2000 MTC data)
Transit Access (HMi)	Accessibility by transit during peak conditions from the area within ½ mile of where the household is located to all employment	Fehr & Peers (calculated in 2011 using 2000 MTC data)
NMT Access (HMi)	Accessibility by NMT during peak conditions from the area within ½ mile of where the household is located to all employment	Fehr & Peers (calculated in 2011 using 2000 MTC data)
Parking Cost	Hourly parking rate paid by long-term parkers in the TAZ where the household is located (2000 cents)	MTC (2000)
Auto Transit Accessibility Ratio	Indicator of auto to transit accessibility for the TAZ where the household is located	Fehr & Peers (calculated in 2011 using 2000 MTC data)

Auto Transit Ratio (HMi)	Indicator of auto to transit accessibility for the area within ½ mile of where the household is located	Fehr & Peers (calculated in 2011 using 2000 MTC data)
TAZ Accessibility	Accessibility of the TAZ in which the household is located based on attractions per TAZ and distance between TAZs	Fehr & Peers (calculated in 2011 using 2000 MTC data)
HH Accessibility	Accessibility of the area within ½ mile of where the household is located based on attractions per TAZ and distance between TAZs	Fehr & Peers (calculated in 2011 using 2000 MTC data)
High Accessibility	Binary variable that equals 1 if the HH Accessibility is higher than the average and equals 0 otherwise	Fehr & Peers (calculated in 2011 using 2000 MTC data)

Diversity Calculation:

The diversity variables (*Diversity TAZ* and *Diversity HMi*) measure the diversity of land use types by analyzing the mix of residents and employees in an area. The variables range in value from 0 to 1, where values closer to 1 indicate a more diverse mix of uses. The diversity variables were calculated as follows:

Diversity =

For the *Diversity TAZ* variable:

- b = regional employment / regional population
- p = population of TAZ where household is located
- e = employees (jobs) in TAZ where household is located

For the *Diversity HMi* variable:

- b = regional employment / regional population
- p = population within ½ mile of household
- e = employees (jobs) within ½ mile of household

Accessibility Calculation:

The accessibility variables *Auto Accessibility TAZ*, *Transit Accessibility TAZ*, and *NMT Accessibility TAZ* describe the ease of traveling from the traffic analysis zone (TAZ) of origin to all of the other TAZs in the Bay Area using the specified mode. The variables *Auto Access HMi*, *Transit Access HMi*, and *NMT Access HMi* measure the average accessibility for the area within ½ mile of where the household is located. The variables are unitless and range in value from 0 to 13.1, where higher values indicate higher accessibility.

The TAZ-based accessibility variables were provided by MTC. A TP+ script was run to compute these variables. To calculate the variables, first an employment variable is multiplied by a mode-specific decay function. The product reflects the difficulty of accessing the activities the farther (in terms of round-trip travel time) the jobs are from the location in question. The products to each destination zone are next summed over each origin zone, and the logarithm of the product mutes large differences. The decay function on the walk accessibility measure is steeper than automobile or transit. The minimum accessibility is zero. Level-of-service variables from three of MTC's five time periods are used in the script, specifically the AM peak period, the midday period, and the PM peak period. (The five time periods are: (a) early AM, 3 am to 6 am; (b) AM peak

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period, 6 am to 10 am; (c) midday, 10 am to 3 pm; (d) PM peak period, 3 pm to 7 pm; and, (e) evening, 7 pm to 3 am the next day.)

The script takes the following inputs:

(A) Highway skims for the AM peak period, midday period, and PM peak period are used. Each skim is expected to include a table named "TOLLTIMEDA", which is the drive alone in-vehicle travel time for automobiles willing to pay a "value" (time-savings) toll. This path is used as a proxy for automobile travel time.

(B) Transit skims for the AM peak period, midday period, and PM peak period are used. Each skim is expected to include the following tables: (i) "IVT", in-vehicle time; (ii) "IWAIT", initial wait time; (iii) "XWAIT", transfer wait time; (iv) "WACC", walk access time; (v) "WAUX", auxiliary walk time; and, (vi) "WEGR", walk egress time. The skims are from the transit paths in which all line-haul modes are weighted equally.

(C) Zonal data file in DBF format (so that header columns can be read), which must include the following variables: (i) "TOTEMP", total employment; (ii) "RETEMPN", retail trade employment per the NAICS classification.

The script file produces the following outputs:

(A) CSV file with the following data items (note the accessibility measures are relative and unit-less):
(i) taz, travel analysis zone number;
(ii) autoPeakRetail, the accessibility by automobile during peak conditions to retail employment for this TAZ;
(iii) autoPeakTotal, the accessibility by automobile during peak conditions to all employment;
(iv) autoOffPeakRetail, the accessibility by automobile during off-peak conditions to retail employment;
(v) autoOffPeakTotal, the accessibility by automobile during off-peak conditions to all employment;
(vi) transitPeakRetail, the accessibility by transit during peak conditions to retail employment;
(vii) transitPeakTotal, the accessibility by transit during peak conditions to all employment;
(viii) transitOffPeakRetail, the accessiblity by transit during off-peak conditions to retail employment;
(ix) transitOffPeakTotal, the accessiblity by transit during off-peak conditions to all employment;
(x) nonMotorizedRetail, the accessibility by walking during all time periods to retail employment;
(xi) nonMotorizedTotal, the accessibility by walking during all time periods to all employment.

The half mile based accessibility variables were calculated by Fehr & Peers by proportionally aggregating the TAZ-based accessibility variables for the area within a ½ mile radius of each household. Therefore each household has a unique value for the half mile based accessibility variables.

<u>Auto-Transit Accessibility Calculation:</u>

Auto Transit Accessibility Ratio is a variable comparing the accessibility by auto to the accessibility by transit. The variable ranges from 0 to 1 where higher values mean the location is increasingly more accessible by auto than by transit. The variables are calculated as follows:

Auto Transit Accessibility Ratio =

Auto Transit Ratio HMi =

2.2 Vehicle Trip Rate Models

Several iterations of regressions were run to determine the best model for estimating vehicle trip rates. Average weekday car driver trips were calculated for each household in the BATS survey to be used as the dependent variable for this analysis. BATS data were collected over a period of two days. Data were collected on all trips by persons in the household. Weekend trips were removed. Weekday trips made by a car driver (either drive alone or carpool) were aggregated to the household level. This two day sum of household trips was divided by two to get average daily household car driver trips.

First analysis was performed to determine the most appropriate population to analyze (Section 2.2.1). Next ordinary least squares (OLS) and negative binomial regression techniques were compared to determine which was most appropriate for the analysis (Section 2.2.2). Finally, various accessibility and demographic variables were tested to develop a suite of modeling options as well as an overall preferred model (Section 2.2.3).

2.2.1 Selection of Population

OLS regression models were run for three population categories: all households, households within one mile of a rail station, and households within ½ mile of a rail station in order to analyze whether the factors influencing vehicle trip rates are different between the general population and those living near rail stations. The variables listed in **Table 2** were entered into the models. Density and accessibility variables were calculated for the area within a ½ mile radius of each household. However, regressions were also run using density and accessibility variables for the TAZ in which the household is located. The first method is preferable in order to provide unique values for each household and to avoid clustering of variables within the same TAZ. However, if data for the ½ mile area around each household is not available, the models using TAZ data can be used instead. In addition, the model results presented below do not include the variable household vehicles as an input since many jurisdictions to not presently have this data readily available. However, regressions were also run including this variable and can be used if data on household vehicles is available. The results of all of the regression runs can be seen in **ATTACHMENT 4.1 below**.

The coefficients for the preferred models are summarized in **Table 3**.

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Table 3: Vehicle Trip Rate Model Coefficients

Dependent Variable: Average Daily Household Car Driver Trips			
Coefficients	**Model 1: All Households**	**Model 2: Households within 1 Mile of a Rail Station**	**Model 3: Households within 1/2 Mile of a Rail Station**
Household Size	0.968	0.901	0.811
Low Income	-0.862	-0.714	-0.772
Owner	0.773	0.745	0.627
Activity Density	-0.010	-0.004	-0.006
Auto Access	0.210	0.352	
Transit Access	-0.053	-0.172	-0.249
NMT Access		-0.178	
Trains per Day	-0.001	-0.001	
ln(Distance to Rail)	0.091		
(Constant)	-0.221	0.091	3.442
N*	14,686	2,760	1,062
Adjusted R^2	0.243	0.282	0.243

*Size of sample population, records with missing values for any of the coefficients were excluded

Model 2 has the highest adjusted R^2 of the three models. Model 2 has higher coefficients for the accessibility variables than Model 1, indicating that vehicle trip generation of those who live near rail stations is more sensitive to accessibility than members of the general population. In addition, NMT accessibility is significant for Model 2 but not for Model 1. Fewer variables were found to be significant in Model 3. This could be due to the smaller sample size, which makes it more difficult to identify statistically significant relationships. Generally the coefficients are similar between the three models. One main difference is that the coefficient for Transit Access is larger for Model 3 than for the other two models, which would suggest that improvements in transit accessibility have a larger reduction on vehicle trip rates for those who live within ½ mile of a rail station than for those who live further. Model 1 contains the variable ln(Distance to Rail), which factors in the distance of a household to a rail station. For households within 1 mile of a rail station, this variable will be negative, reducing the estimated car driver trips per household. For households further than 1 mile from a rail station, this variable will be positive, but will increase at a decreasing rate with increasing distance to rail, indicating that households further from rail will have an increased car driver trip rate, but the further a household is from a rail station, the smaller the effect this distance has on the trip rate of the household.

Since the R^2 value is similar for all three models and since there is little variation in the coefficients, it is suggested to use the entire BATS population to develop a vehicle trip rate model rather than only using the population of those living near rail corridors. The model should include the variable ln(Distance to Rail) to factor in the distance of a household to the nearest rail station.

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2.2.2 Selection of Regression Technique

Members of an Expert Panel reviewed the analysis in Section 2.2.1 and recommended testing the negative binomial (NBN) regression technique in addition to OLS regression since negative binomial regression is often well suited for predicting count variables such as number of vehicle trips. In OLS Regression, the dependent variable is assumed to be a linear function of one or more independent, identically distributed variables plus an error to account for all other factors. NBN are well suited for building models where the variances of the explanatory variables (or independent variables) do not equal the mean outcome. Moreover, the negative binomial process results from a mixture of Poisson processes, in other words, the compilation of multiple variables that show Poisson distributions with varying means results in an over dispersed Poisson distribution (i.e., a negative binomial distribution). A requirement of NBN is that the dependent variable is a count or integer variable. For the dependent variable in Section 2.2.1, the two day sum of household trips was divided by two to get average daily household car driver trips. However, in the following models the two day sum is used because integer values are required for the dependent variable in NBN regression models.

Additionally, two new dummy indicator variables were tested: Zero Car HH and Multi Family Dwelling. The models were also run both with and without physical “D” variables; this comparative model framework was recommended by one member of the Panel members as a means of quantifying the extent to which demographic and socioeconomic factors affect travel behavior. The larger coefficients for variables in the models without “D” variables suggest the degree of influence that self-selection of residential location in relation to transport opportunities has on travel outcomes.

Table 4 provides a summary of the coefficients from each of the models as well as their R^2 values. The population used in the models is the entire BATS survey, 14,686 households. Model outputs are provided in **Attachment 4.2**.

Table 4: Vehicle Trip Rate Model Outputs Comparison

	Model 1: OLS with Ds	**Model 2: Negative Binomial with Ds**	**Model 3: OLS without Ds**	**Model 4: Negative Binomial without Ds**
Constant	0.434	1.210	-0.235	1.091
Household Size	1.860	0.204	1.983	0.227
Low Income	-1.304	-0.191		
Owner	1.058	0.106		
Activity Density	-0.007	-0.003	-0.020	-0.006
Auto Access	0.399	0.047	0.526	0.062
Transit Access	-0.114	-0.007	-0.168	-0.010
Trains per Day	-0.001	0.000	-0.002	0.000
Ln(Rail Distance)	0.144	0.017	0.124	0.014
Zero Car HH	-4.494	-2.787		
Multi Family Dwelling	-0.753	-0.109	-1.580	-0.213
R-Square	0.261	0.035[1]	0.229	0.020[1]

McFadden’s R^2 is used for Negative Binomial Regressions

As the outputs show, the OLS models provide a much better goodness of fit, or R^2 value, than NBN. One reason may be that NBN typically work better with independent variables with a Poisson distribution. However, very few of the independent variables entered into the model follow a Poisson distribution. Based on this analysis, OLS Regression is a better fit for the data than NBN. Therefore the OLS Regression results are recommended for the Vehicle Trip Models.

2.2.3 Selection of Accessibility Variables

Eight new accessibility variables were also calculated by Fehr & Peers. These accessibility variables are simpler and faster to create than the half mile based accessibility variables described in Section 2.1. The first four variables calculate an accessibility value per TAZ. Two attractions accessibility variables take into consideration the number of attractions per TAZ and the distance between TAZs and two productions accessibility variables take into consideration the number of productions per TAZ and the distance between TAZs. These were calculated both for all trips and for Home-Based Trips, which include both home-based work trips and home-based other trips. The equations for calculating each of these four variables are described below.

where
R_n = Productions accessibility for TAZ n
P_i = Total number of productions in TAZ i
$D_{n,i}$ = Distance from TAZ n to TAZ i in miles

where
S_n = Attractions accessibility for TAZ n
A_i = Total number of attractions in TAZ i
$D_{n,i}$ = Distance from TAZ n to TAZ i in miles

where
T_n = Home-based productions accessibility for TAZ n
PH_i = Total number of home-based productions in TAZ i
$D_{n,i}$ = Distance from TAZ n to TAZ i in miles

where
U_n = Home-based attractions accessibility for TAZ n
AH_i = Total number of home-based attractions in TAZ i
$D_{n,i}$ = Distance from TAZ n to TAZ i in miles

These four accessibility variables were then assigned to households based on the TAZ in which the household is located. Next these four accessibility variables were proportionally aggregated to the area within ½ mile of each household to calculate unique accessibility variables for each household. A summary of the value ranges can be seen in **Table 5**.

All of the variables created are correlated to each other, so only one at a time can be used as an independent variable in an OLS regression model. The variables with the highest significance values were the total attractions based accessibility variables, so these were the variables used in the regression analysis.

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Table 5: Value Range of Accessibility Variables			
	Minimum	**Maximum**	**Mean**
Total Attractions Accessibility per TAZ* (*TAZ Accessibility*)	.24	4.36	1.07
Total Productions Accessibility per TAZ	.24	2.53	1.04
Home Based Attractions Accessibility per TAZ	.18	1.51	.74
Home Based Productions Accessibility per TAZ	.18	3.11	.77
Total Attractions Accessibility per HH* (*HH Accessibility*)	.16	2.34	1.03
Total Productions Accessibility per HH	.16	3.46	1.06
Home Based Attractions Accessibility per HH	.11	1.46	.73
Home Based Productions Accessibility per HH	.11	2.47	.76
*Variables used in OLS regressions			

OLS regression analysis was run on the entire BATS survey population including a total of 14,868 households. The dependent variable used was the two day sum of household vehicle driver trips divided by two to get the daily average. Various models were run using different combinations of accessibility variables. The model results can be seen in **ATTACHMENT 4.3**. **Table 6** shows the results of OLS regression models. Model 1 includes the half mile based MTC auto and transit accessibility variables described in section 2.1 as independent variables. Model 2 includes Total Attractions Accessibility per TAZ (TAZ Accessibility) as an independent variable and Model 3 includes Total Attractions Accessibility per HH (HH Accessibility) as an independent variable. Model 4 includes a simplified accessibility variable that equals 1 if the household is in an area with high accessibility and 0 otherwise. Model 2 and Model 3 are very similar; between these two, Model 3 is preferred because using the household based accessibility variable included in Model 3 may help reduce problems of heteroscedasticity. Model 4 can be used in cases where a more detailed accessibility variable per household cannot be calculated. The coefficients for TAZ Accessibility and HH Accessibility are slightly higher than that for Auto Access. The coefficients for other independent variables are similar between the four models.

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Table 6: Vehicle Trip Rate Model Outputs Comparison				
	Model 1: (recommended)	**Model 2:**	**Model 3:**	**Model 4:**
Constant	0.217	1.909	1.901	2.178
Household Size	0.930	0.935	0.935	0.933
Low Income	-0.652	-0.670	-0.672	-0.683
Owner	0.529	0.551	0.552	0.555
Activity Density	-0.004	-0.007	-0.007	-0.004
Trains per Day	-0.001	-0.001	-0.001	-0.001
Ln(Rail Distance)	0.072	0.086	0.088	0.064
Zero Car HH	-2.247	-2.260	-2.260	-2.249
Multi Family Dwelling	-0.377	-0.390	-0.385	-0.377
Auto Access (MTC)	0.200	-	-	-
Transit Access (MTC)	-0.057	-	-	-
TAZ Accessibility (F&P)	-	0.353	-	-
HH Accessibility (F&P)	-	-	0.361	-
High Accessibility	-	-	-	0.122
R-Square	0.261	0.259	0.259	0.259

Table 7 shows the results of OLS regression models similar to Models 1-4 but with demographic and household vehicle variables removed. Model 6 and Model 7 are very similar. Again, the coefficients for TAZ Accessibility and HH Accessibility are slightly higher than that for Auto Access. The coefficients for other independent variables are similar between the four models.

Table 7: Vehicle Trip Rate Model Outputs Comparison				
	Model 5:	**Model 6:**	**Model 7:**	**Model 8:**
Constant	-0.118	2.047	2.067	2.441
Household Size	0.992	1.001	1.001	0.999
Activity Density	-0.010	-0.016	-0.015	-0.011
Trains per Day	-0.001	-0.001	-0.001	-0.001
Ln(Rail Distance)	0.062	0.095	0.094	0.060
Multi Family Dwelling	-0.790	-0.828	-0.822	-0.813
Auto Access (MTC)	0.263	-	-	-
Transit Access (MTC)	-0.084	-	-	-
TAZ Accessibility (F&P)	-	0.501	-	-
HH Accessibility (F&P)	-	-	0.482	-
High Accessibility	-	-	-	0.157
R-Square	0.229	0.226	0.226	0.226

Overall we would recommend **Model 1** as the preferred model because it has the highest R^2 value. However, since the Auto Access and Transit Access variables might be difficult to calculate, the HH Accessibility was created as a simpler alternative. In the case that Auto Access and Transit Access cannot be calculated, Model 3 should be used instead. If the household distance based accessibility variable cannot be calculated, Model 4 should be used.

2.3 Household VMT Models

Average weekday vehicle miles traveled (VMT) were calculated for each household in the BATS survey to be used as the dependent variable in OLS regression analysis. BATS survey data includes information about trip origin and destination locations. TAZ to TAZ skim distance estimates provided by MTC across the 2000 road network were used to estimate trip distance for each weekday trip by a car or carpool driver in the BATS survey. These car driver trip distances were then aggregated by household to get average daily weekday VMT per household.

Similar to the vehicle trip rate analysis described in Section 2.2.1, first analysis was performed to determine the most appropriate population to analyze (Section 2.3.1). Next various household vehicle variables were compared to determine which was most appropriate for the analysis (Section 2.3.2). Finally, various accessibility variables were tested to determine the overall preferred model (Section 2.3.3).

2.3.1 Selection of Population

OLS regression models were run for three population categories: all households, households within one mile of a rail station, and households within ½ mile of a rail station in order to analyze whether household VMT is different between the three populations. The variables listed in **Table 2** were tested. Similar to the vehicle trip rate models, several versions of the household VMT models were run including models with density and accessibility variables both for the area within ½ mile of the household and for the TAZ in which the household is located, as well as models both with and without household vehicles. A summary of the model coefficients can be seen in **Table 8**. The model results can be seen in **ATTACHMENT 4.4**.

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Table 8: VMT Model Coefficients				
Dependent Variable: Average Daily Household VMT				
	Model 1a: All Households	**Model 1b: All Households**	**Model 2: Households within 1 Mile of a Rail Station**	**Model 3: Households within 1/2 Mile of a Rail Station**
Household Size	6.166	6.212	4.927	4.693
Low Income	-12.893	-12.650	-9.483	-9.965
Owner	2.258	2.382	3.441	4.254
Activity Density	-.060	-0.060	-0.042	-0.041
Auto Transit Access Ratio	20.556	23.517	27.539	27.118
Distance to Rail	0.100			
Diversity	-5.386			
(Constant)	12.450	8.088	6.927	7.638
N*	14,420	14,420	2,690	1,023
Adjusted R^2	0.166	0.165	0.149	0.134
*Size of sample population, records with missing values for any of the coefficients were excluded				

The adjusted R^2 values for the VMT models are fairly low, meaning the majority of variation in household VMT is not explained by the models. However, statistically significant relationships were found between several independent variables and household VMT. For the overall population, eight variables entered into the model as significant (Model 1a in **Table 8**). However, for the population within 1 mile of a rail station and the population within ½ mile of a rail station, only six variables entered into the models as significant (Model 2 and Model 3 in **Table 8**). A regression with these six variables was run for the entire population for comparison purposes (Model 1b in **Table 8**). The coefficients for household size and low income are smaller for Model 2 and Model 3 than for Model 1b. This suggests that those variables have a smaller impact on household VMT for populations living near rail corridors than for the general population. However, the ownership status of a household has a larger impact on VMT for those living along a rail corridor than for the general population. Furthermore, the ratio of auto to transit accessibility has a larger impact on household VMT for those living near rail corridors than for the general population.

Since Model 1a has the highest adjusted R^2 value, and since the coefficients do not vary greatly between the models, it is suggested to use the entire BATS population to develop a VMT model rather than only using the population of those living near rail corridors. The model should include the variable Distance to Rail to factor in the distance of a household to the nearest rail station.

2.3.2 Analysis of Household Vehicles and VMT

Number of household vehicles was found to be a significant predictor of household VMT. However, not all regional planning agencies can forecast vehicle ownership per household. Agencies that do have data for vehicle ownership can use models that include this variable in near-term analyses. For future years, jurisdictions agencies would first need to predict vehicle ownership per household and then, in a subsequent step predict household VMT.

The following regression models were run for use in this analysis, each using household VMT as the dependent variable:

- Model 1: all 14,420 households used as inputs, number of vehicles per household included as an independent variable
- Model 2: all 14,420 households used as inputs, a binary variable representing zero-car households included as an independent variable
- Model 3: all 14,420 households used as inputs, no vehicle-related independent variables included
- Model 4: 13,852 households with at least one car used as inputs, no vehicle-related independent variables included
- Model 5: 568 households with zero cars used as inputs, no vehicle-related independent variables included

The coefficients for each of the models are summarized in **Table 9**. The model outputs are provided in **Attachment 4.5**.

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Table 9: Household VMT Model Outputs Comparison

	Model 1: (recommended) All HH	Model 2: All HH	Model 3: All HH	Model 4: HH with Cars	Model 5: Zero Car HH
Constant	4.229	12.554	12.450	13.378	-1.392
Household Size	3.474	6.071	6.166	6.112	1.086
Low Income	-8.992	-11.552	-12.893	-12.250	-0.468*
Auto Transit Ratio	17.639	20.969	20.556	20.269	2.373*
Owner	-1.054	1.697	2.258	1.574	-0.088*
Diversity	-5.042	-5.493	-5.386	-5.548	0.955*
Distance to Rail	0.102	0.099	0.100	0.106	-0.023*
Activity Density	-0.018	-0.018*	-0.060	-0.044	-0.002*
HH Vehicles	8.892	-	-	-	-
Zero Car HH	-	-14.302	-	-	-
N**	14,420	14,420	14,420	13,852	568
R-Square	0.208	0.172	0.167	0.143	0.032

*Significance value > 0.2

**Size of sample population, records with missing values for any of the coefficients were excluded

The results show that separating households into two groups: households with cars and households without cars, does not improve the significance of the models. Furthermore, there is not enough data on zero car households to create a significant model of household VMT. Therefore it is suggested to use the entire BATS population to develop a VMT model and to use the variable HH Vehicles if available.

2.3.3 Selection of Accessibility Variables

The accessibility variables described in Section 2.2.3 were also tested in the VMT regression models. **Table 10** shows the results of OLS regression models with average daily VMT per household as the dependent variable. All models use the entire BATS survey for a total of 14,420 households. Model results can be seen in **ATTACHMENT 4.6**. Model 1 does not include the MTC auto or transit accessibility variables as independent variables but does include the ratio of auto to transit accessibility. Model 2 includes TAZ Accessibility as an independent variable, Model 3 includes HH Accessibility as an independent variable, and Model 4 includes a binary variable indicating high accessibility. Model 2 and Model 3 are very similar but the accessibility coefficient in Model 2 is larger. Also, in Models 2 and 3 the variable Distance to Rail is no longer significant and the sign for Activity Density has changed from negative to positive. In Model 4 the sign for Activity Density is negative but the significance of the variable is reduced. Based on these results we would not recommend including the accessibility variables in the VMT models.

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Table 10: Household VMT Model Outputs Comparison

	Model 1: (recommended)	Model 2:	Model 3:	Model 4:
Constant	4.229	17.866	15.806	8.048
Household Size	3.474	3.391	3.412	3.454
Low Income	-8.992	-9.432	-9.316	-9.052
Auto Transit Ratio	17.639	11.913	12.790	14.175
Owner	-1.054	-1.122	-1.077	-1.107
Diversity	-5.042	-3.927	-3.962	-4.875
Distance to Rail	0.102	-.001*	0.011*	0.072
Activity Density	-0.018	0.097	0.082	-0.015*
HH Vehicles	8.892	8.805	8.840	8.908
TAZ Accessibility (F&P)	-	-11.298	-	-
HH Accessibility (F&P)	-	-	-9.890	-
High Accessibility	-	-	-	-3.427
R-Square	0.208	0.211	0.210	0.209

*Significance value > 0.2

Overall we would recommend **Model 1** as the preferred model because all of the variables are significant and the coefficients have the expected sign.

3.0 MODE SPLIT ANALYSIS AND RAIL STATION ORIGIN AND DESTINATION MODELS

This section summarizes analysis of work and non-work mode splits. In addition, models were developed to estimate mode share for trips with a destination near a rail station. Data from the 2000 Bay Area Travel Survey (BATS) were used. Overall, 67,881 trips had a work origin or destination. BATS survey data were available for 133,438 non-work trips. Of these, 77,041 had a non-home destination.

3.1 Work Trip Mode Split Analysis

Work trips near rail stations have a much lower car mode share and higher rail and walking mode shares than overall work trips. The car driver mode share for all work trips is 78 percent, for work trips within ½ mile of a rail station is 54 percent and for work trips within ¼ mile of a rail station is 44 percent. Rail mode share for all work trips is 5 percent, for work trips within ½ mile of a rail station is 16 percent and for work trips within ¼ mile of a rail station is 20 percent. Walk mode share for all work trips is 6 percent, for work trips within ½ mile of a rail station is 14 percent and for work trips within ¼ mile of a rail station is 18 percent. Mode share of car passenger trips is 6 percent for all three categories. Furthermore, trips that have both a trip origin and destination within ½ mile of a rail station (and one of the trip ends is a work trip) have an even lower car driver mode share and a much higher walk mode share.

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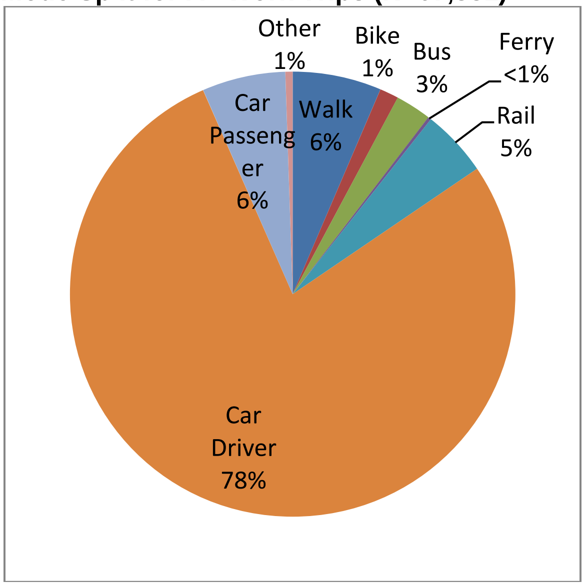
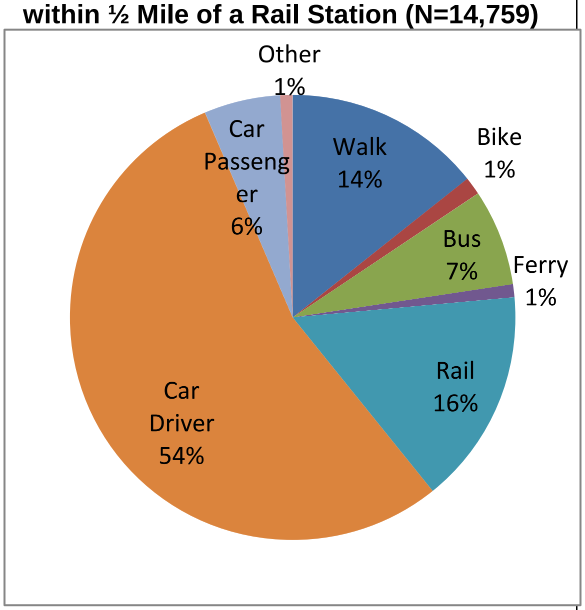
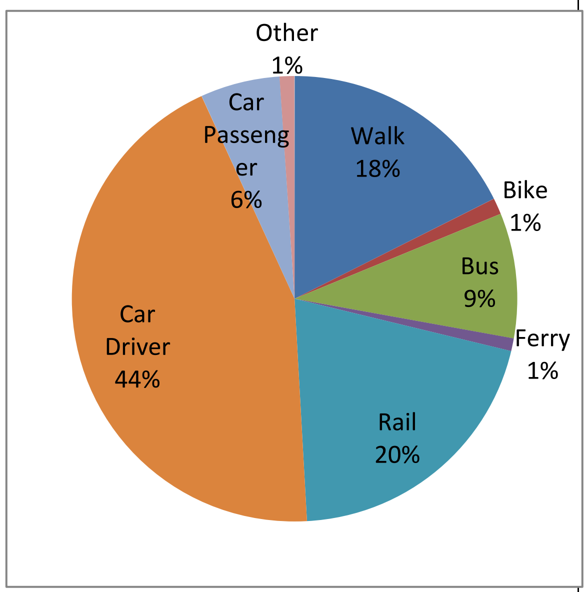
Mode Split for All Work Trips (N=67,881)



Trips with a Work Origin or Destination within ½ Mile of a Rail Station (N=14,759)



Trips with a Work Origin or Destination within ¼ Mile of a Rail Station (N=6,162)



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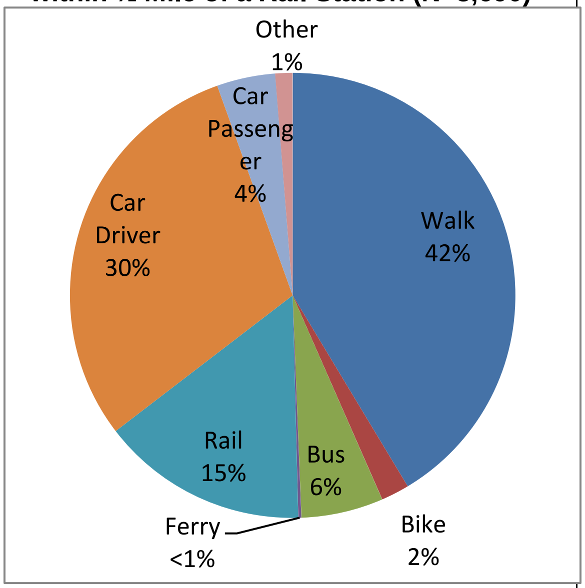
Work Trips with Origin and Destination within ½ Mile of a Rail Station (N=3,690)



Work Trips with Origin and Destination within ¼ Mile of a Rail Station (N=1,099)

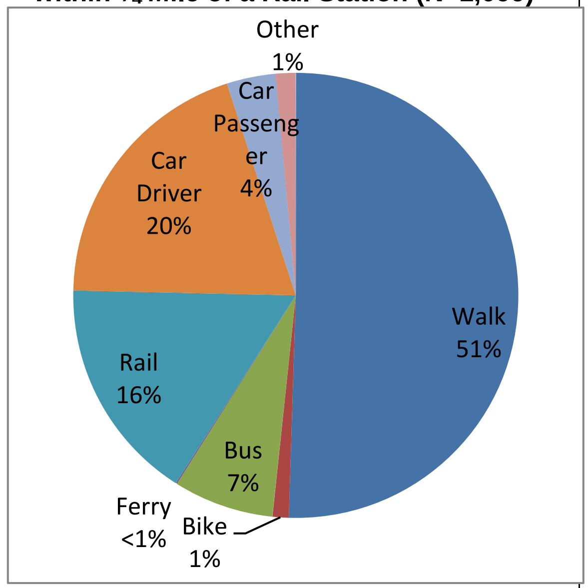


Table 11 and Table 12 provide a summary of work mode split by rail corridor. The Muni light rail corridor has the lowest car mode split and the highest rail mode split, followed by the BART corridor. However, along the VTA, Caltrain, Amtrak and ACE corridors, car trips still dominate the commute trip. For almost all of the corridors, the car mode split for those living within ¼ mile of a rail station is lower than for those living within ½ mile of a station, and the rail mode share is higher.

Table 11: Work Mode Split by Rail Corridor within ½ Mile of a Station

	Trips with a work trip end within ½ mile of:						
	Composite Rail Station	**SF Muni Station**	**BART Station**	**VTA Station**	**Caltrain Station**	**Amtrak Station**	**ACE Station**
Walk	14%	22%	15%	4%	9%	11%	9%
Bike	1%	1%	3%	1%	0%	2%	0%
Bus	7%	13%	7%	1%	2%	1%	1%
Ferry	1%	2%	0%	0%	0%	1%	0%
Rail	16%	26%	18%	3%	4%	5%	1%
Car Driver	54%	29%	51%	85%	78%	74%	87%
Car Passenger	6%	6%	5%	6%	6%	7%	3%
Other	1%	1%	1%	0%	1%	1%	1%
N	14,759	5,521	3,700	2,968	2,056	398	195

Table 12: Work Mode Split by Rail Corridor within ¼ Mile of a Station

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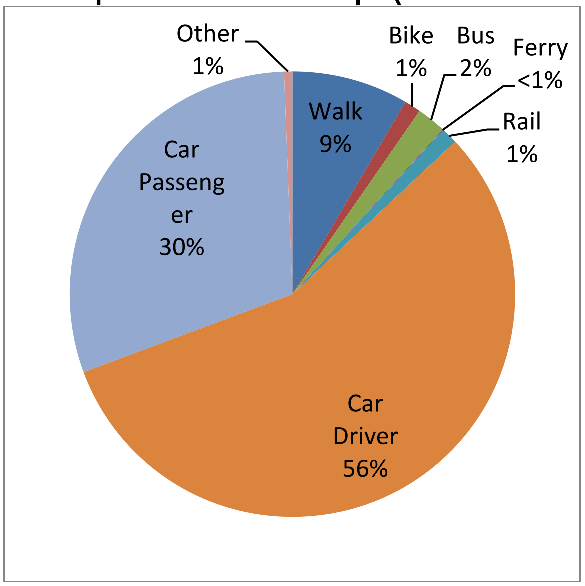
	Trips with a work trip end within ¼ mile of:						
	Composite Rail Station	**SF Muni Station**	**BART Station**	**VTA Station**	**Caltrain Station**	**Amtrak Station**	**ACE Station**
Walk	18%	22%	17%	7%	9%	12%	15%
Bike	1%	1%	3%	0%	0%	0%	0%
Bus	9%	13%	8%	1%	1%	0%	1%
Ferry	1%	2%	0%	0%	0%	0%	0%
Rail	20%	27%	25%	3%	8%	5%	0%
Car Driver	44%	28%	42%	80%	75%	79%	79%
Car Passenger	6%	6%	4%	8%	6%	3%	3%
Other	1%	1%	1%	1%	1%	1%	2%
N	6,162	3,387	1,103	885	573	139	86

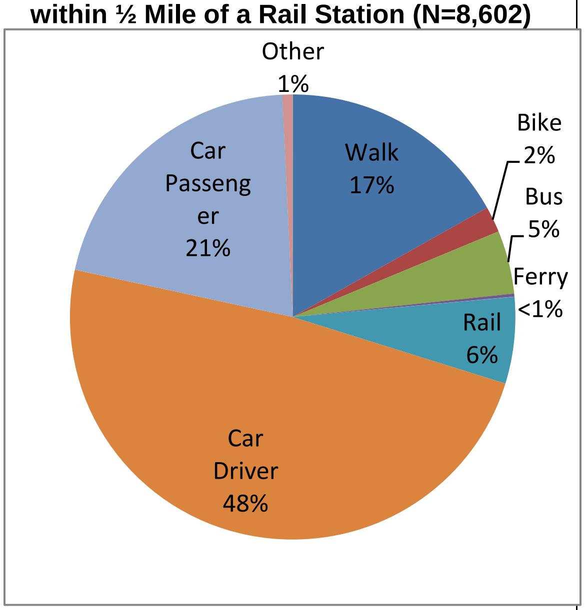
3.2 Non-Work Trip Mode Split Analysis

BATS survey data were available for 133,438 non-work trips. Of these, 77,041 had a non-home destination; these trips were used for the analysis. Non-work trips with a destination within ½ or ¼ mile of a rail station have a lower car mode share, a higher transit mode share and a higher walk mode share than overall non-work trips. Car driver mode share for all non-work trips is 56 percent, for trips with a destination within ½ mile of a rail station is 48 percent and for trips with a destination within ¼ mile of a rail station is 44 percent. Rail mode share for all non-work trips is 1 percent, for trips with a destination within ½ mile of a rail station is 6 percent and for trips with a destination within ¼ mile of a rail station is 9 percent. Walk mode share for all non-work trips is 9 percent, for trips with a destination within ½ mile of a rail station is 17 percent and for trips with a destination within ¼ mile of a rail station is 20 percent. Non-work trips with both an origin and destination within ½ mile of a rail station have an even higher walk mode share and a lower car mode share; however rail mode share remains about the same as for trips with a destination within ½ mile of a rail station.

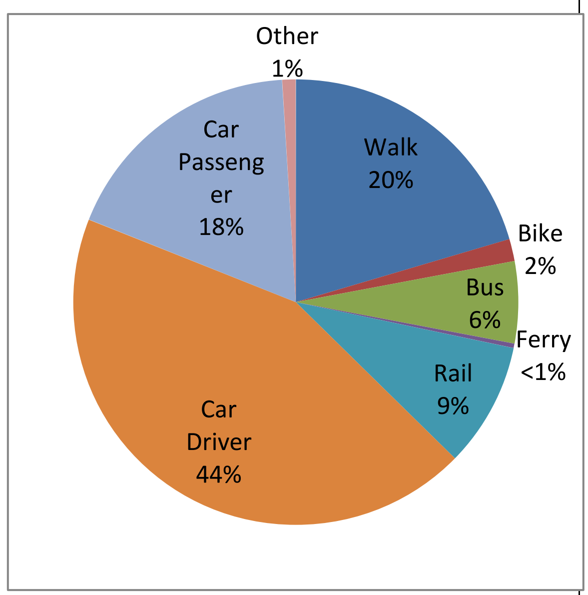
Mode Split for Non-Work Trips (without home destination) (N=77,041)



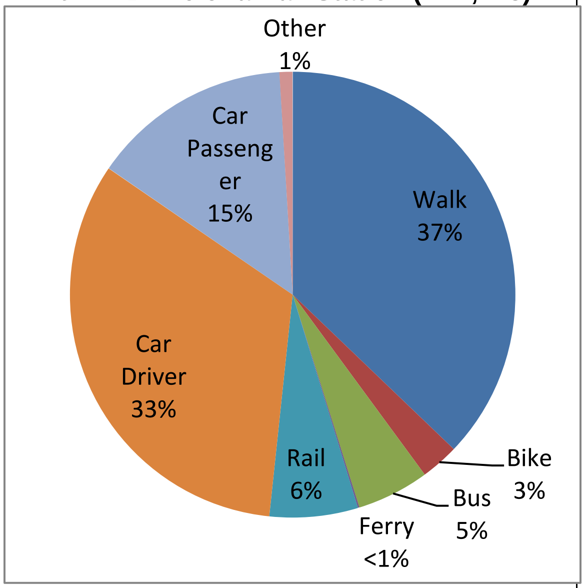
Trips with a Non-Work Trip Destination within ½ Mile of a Rail Station (N=8,602)



Trips with a Non-Work Trip Destination within ¼ Mile of a Rail Station (N=3,770)



Non-Work Trips with Origin and Destination within ½ Mile of a Rail Station (N=2,748)



Non-Work Trips with Origin and Destination within ¼ Mile of a Rail Station (N=885)

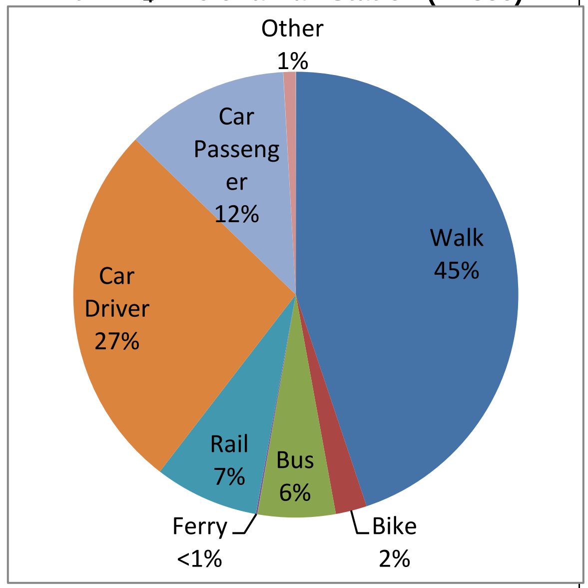


Table 13 and **Table 14** provide a summary of non-work mode split by rail corridor. The Muni light rail corridor has the lowest car mode split and the highest rail mode split, followed by the BART corridor. However, along the VTA, Caltrain, Amtrak and ACE corridors, car trips still dominate for non-work trips. For almost all of the corridors, the car mode split for those living within ¼ mile of a rail station is lower than for those living within ½ mile of a station, and the rail mode share is higher.

Table 13: Non-Work Mode Split by Rail Corridor within ½ Mile of a Station

	Trips with a destination within 1/2 mile of:						
	Any Rail Station	SF Muni Station	BART Station	VTA Station	Caltrain Station	Amtrak Station	ACE Station
Walk	17%	26%	18%	8%	9%	6%	4%
Bike	2%	2%	3%	1%	1%	2%	1%
Bus	5%	8%	4%	3%	1%	1%	1%
Ferry	0%	1%	0%	0%	0%	0%	0%
Rail	6%	12%	6%	3%	2%	1%	0%
Car Driver	48%	34%	48%	60%	61%	64%	63%
Car Passenger	21%	16%	20%	24%	25%	25%	30%
Other	1%	1%	1%	1%	1%	1%	1%
N	8,602	2,771	2,495	788	2,074	220	254

Table 14: Non-Work Mode Split by Rail Corridor within ¼ Mile of a Station

	Trips with a destination within ¼ mile of:						
	Any Rail Station	**SF Muni Station**	**BART Station**	**VTA Station**	**Caltrain Station**	**Amtrak Station**	**ACE Station**
Walk	20%	26%	21%	10%	10%	3%	5%
Bike	2%	1%	2%	2%	2%	2%	1%
Bus	6%	8%	6%	1%	1%	2%	2%
Ferry	0%	1%	0%	0%	0%	0%	0%
Rail	9%	13%	8%	3%	4%	1%	0%
Car Driver	44%	34%	45%	63%	59%	73%	58%
Car Passenger	18%	16%	17%	20%	23%	19%	33%
Other	1%	1%	1%	1%	1%	0%	1%
N	3,770	1,908	821	286	556	97	102

3.3 Station Area Mode Split Analysis and Modeling

Mode split of trips made to each station area were analyzed to determine relationships between station area characteristics and mode split. A total of 146 station areas were analyzed, including rail stations for the following transit agencies: SF Muni, BART, VTA, Caltrain, Amtrak, and ACE. A station area was defined as the area within a ½ mile radius of the station. The models estimate car driver and transit mode share for both work and non-work trips to the station area. For each of the models the dependent variable falls between 0 and 1. For example, for any given station area between 0% and 100% of trips to the station area will be made by car driver; values outside of this range are not possible. Therefore the model results must have an upper bound and a lower bound. Two types of models were used for these estimates: OLS Regression Model and Tobit Model.

OLS Regression models can be used to estimate continuous dependent variables. The dependent variables in the following models are continuous between 0 and 1. When applying the models, values estimated to be below 0 should be assigned a value of 0 while values estimated to be above 1 should be assigned a value of 1. This will generally give a good estimate when most of the values estimated fall within the mid range of the boundaries. However, if many values lie along the edge of this boundary, OLS may not be the best estimator. One benefit of using OLS regression is that the results are easy to interpret since the coefficients describe the effect of the independent variables on the dependent variable.

For each of the dependent variables, a Tobit Model was also run. The Tobit Model is a special case of a censored regression model. This model is often used when the dependent variable has an upper and/or lower bound, as is the case with the following models. One issue with this model is that the outputs of the Tobit Model are more difficult to interpret than OLS outputs since the coefficients are a combination of a) The change in the dependent variable above or below the limit, weighted by the probability of being above or below the limit, and b) The change in the probability of being above or below the limit, weighted by the expected value of the dependent variable, if above or below the limit. Additionally, there is no consensus in the literature as to which pseudo-R^2 should be used for Tobit estimation. However, based on the criteria of selecting a pseudo-R^2 measure which is a good predictor of what an OLS R^2 would be on uncensored

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data, Veall and Zimmermann found the McKelvey-Zavoina Pseudo-R^2 to be the best choice.[1] Therefore we use this R^2 value as a goodness of fit measure for the Tobit Model results.

The variables listed in **Table 15** were collected for each station area.

Table 15: Station Area Variables

Variable Name	Description	Source
Trains per Day	Trains per day at station	Fehr & Peers
Parking Cost	Hourly parking rate paid by long-term parkers in the TAZ where the station is located (2000 dollars)	MTC (2000)
Household Density	Household density within ½ mile of the station (households per acre)	Fehr & Peers (calculated in 2011 using 2000 MTC data)
Population Density	Population density within ½ mile of the station (population per acre)	Fehr & Peers (calculated in 2011 using 2000 MTC data)
Employment Density	Employment density within ½ mile of the station (employees per acre)	Fehr & Peers (calculated in 2011 using 2000 MTC data)
Retail Employment Density	Retail employment density within ½ mile of the station (employees per acre)	Fehr & Peers (calculated in 2011 using 2000 MTC data)
Activity Density	Sum of population density and employment density within ½ mile of the station	Fehr & Peers (calculated in 2011 using 2000 MTC data)
Diversity	Jobs/housing diversity indicator within ½ mile of the station	Fehr & Peers (calculated in 2011 using 2000 MTC data)
Auto Accessibility	Accessibility by auto during peak conditions from the area within ½ mile of the station to all employment in the Bay Area	MTC (2000)
Auto Retail Accessibility	Accessibility by auto during peak conditions from the area within ½ mile of the station to retail employment in the Bay Area	MTC (2000)
Transit Accessibility	Accessibility by transit during peak conditions from the area within ½ mile of the station to all employment in the Bay Area	MTC (2000)
Transit Retail Accessibility	Accessibility by transit during peak conditions from the area within ½ mile of the station to retail employment in the Bay Area	MTC (2000)
NMT Accessibility	Accessibility by NMT during all time periods from the area within ½ mile of the station to all employment	MTC (2000)
Auto Transit Accessibility Ratio	Indicator of auto to transit accessibility for the station	Fehr & Peers (calculated in 2011 using 2000 MTC data)
BART	Binary variable indicating the station is a BART station (0/1)	Fehr & Peers

[1] M. Veall and K. Zimmermann, Goodness of Fit Measures in the Tobit Model, *Oxford Bulletin of Economics and Statistics*, 56, 4 (1994)

Since the coefficients of the following models are similar between the OLS models and the Tobit models, and since the outputs of the OLS models are easier to interpret, we suggest using the OLS model results as the preferred models.

3.3.1 Station Area Work Trip Mode Split Models

Using trip data from the BATS survey, mode share of work trips within ½ mile of each of the 146 rail stations in our study area were calculated. Only data for stations with at least 25 work trips within ½ mile of the station were used, for a total of 77 stations. Considering all work trips made to the station area, the percent of those trips made by car driver (either drive alone or carpool) was calculated and this value was used as the dependent variable for the car driver models. Similarly, the percent of work trips made by transit (rail, bus, or ferry), was calculated for each station area and used as the dependent variable for the transit models. The models can be used to estimate the percent of work trips to a station area that are made either by a car driver or by transit, based on various station area characteristics.

Data set: 77 rail stations with at least 25 work trips within ½ mile of the station.

3.3.1.1 Work Trip Car Driver Mode Share Tobit Model

The variables in **Table 8** were entered into a Tobit Model analysis, run in R, in order to estimate the dependent variable: car driver mode share for work trips within ½ mile of a rail station. **Table 16** shows the model outputs.

Table 16: Work Trip Car Driver Mode Share Tobit Model Results

Variable	Coefficient	Std. Error	t value
(Constant)	0.750	0.057	13.171
Parking Cost	-0.118	0.067	-1.768
Auto Transit Access Ratio	0.462	0.182	2.539
HH Density Hmi	-0.007	0.003	-2.358
Emp Density Hmi	-0.001	0.000	-1.617
BART	-0.079	0.032	-2.473

Work Trip Car Driver Mode Share =

y_i = .750 - .118 * Parking Cost + .462 * Auto Transit Access Ratio - .007 * HH Density Hmi - .001 * Emp Density Hmi - .079 * BART + e_i

McKelvey-Zavoina Pseudo-R^2 = 0.724

3.3.1.2 Work Trip Car Driver Mode Share OLS Model

The variables in **Table 15** were entered into an OLS regression analysis, run in SPSS, in order to estimate the dependent variable: car driver mode share for work trips within ½ mile of a rail station. **Table 17** and **Table 18** show the model outputs for the goodness of fit statistics and the coefficients:

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Table 17: Work Trip Car Driver Mode Share OLS Model Goodness of Fit Statistics		
R Square	**Adjusted R Square**	**F Statistic**
0.719	0.699	35.31

Table 18: Work Trip Car Driver Mode Share OLS Model Results – Recommended Model

Coefficients[a]						
		Unstandardized Coefficients		Standardized Coefficients		
Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	.763	.056		13.655	.000
	Parking Cost	-.127	.065	-.279	-1.946	.056
	Auto Transit Ratio	.408	.178	.200	2.291	.025
	HH Density Hmi	-.007	.003	-.202	-2.437	.017
	Emp Density Hmi	-.001	.000	-.203	-1.609	.112
	BART	-.077	.031	-.192	-2.459	.016

a. Dependent Variable: Work Trip Driver Mode Share

Since we are predicting a proportion, we do not want the predicted value to be above 1 or below 0. Therefore, the following equation should be applied:

Work Trip Car Driver Mode Share =

y = .763 - .127 * Parking Cost + .408 * Auto Transit Accessibility Ratio - ..007 * Household Density - .001 * Employment Density - .077 * BART)

The model results can be interpreted as follows:

- As the average, hourly, long-term parking rate in the station area increases by $1, the percent of driver work trips to the station decreases by 13%
- As the auto to transit accessibility ratio of the station area increases, the percent of driver work trips to the station increases
- Every additional increase in household density of one household per acre decreases the percent of car work trips to the station by .7%
- Every additional increase in employment density of 10 jobs per acre decreases the percent of car work trips to the station by 1%

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The percent of driver work trips to BART (or BART-like commuter stations) is 8% lower than for other station types

3.3.1.3 Work Trip Transit Mode Share Tobit Model

The variables in **Table 15** were entered into a Tobit Model analysis, run in R, in order to estimate the dependent variable: transit mode share for work trips within ½ mile of a rail station. **Table 19** shows the model outputs.

Table 19: Work Trip Transit Mode Share Tobit Model Results

Variable	Coefficient	Std. Error	t value
(Constant)	0.236	0.184	1.277
HH Density Hmi	0.004	0.002	1.839
Emp Density Hmi	0.001	0.000	5.367
Auto Access Hmi	-0.041	0.017	-2.378
Transit Access Hmi	0.040	0.010	3.832

Work Trip Transit Mode Share =

y_i = .236 + .004 * HH Density Hmi + .001 * Emp Density Hmi - .041 * Auto Access Hmi + .040 * Transit Access Hmi +e_i

McKelvey-Zavoina Pseudo-R^2 = 0.729

3.3.1.4 Work Trip Transit Mode Share OLS Model

The variables in **Table 15** were entered into an OLS regression analysis, run in SPSS, in order to estimate the dependent variable: transit mode share for work trips within ½ mile of a rail station. **Table 20 and Table 21** show the model outputs for the goodness of fit statistics and the coefficients:

Table 20: Work Trip Transit Mode Share OLS Model Goodness of Fit Statistics

R Square	Adjusted R Square	F Statistic
0.733	0.718	49.36

Table 21: Work Trip Transit Mode Share OLS Model Results - Recommended Model

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	.219	.134		1.629	.108
	HH Density Hmi	.003	.002	.137	1.852	.068
	Emp Density Hmi	.001	.000	.570	7.624	.000
	Auto Access HMi	-.031	.013	-.180	-2.472	.016
	Transit Access HMi	.028	.007	.339	3.737	.000

a. Dependent Variable: Work Trip Transit Mode Share

Since we are predicting a proportion, we do not want the predicted value to be below 0. Therefore, the following equation should be applied:

Work Trip Transit Mode Share =

y = .219 - .031 * Auto Accessibility + .028 * Transit Accessibility + .003 * Household Density + .001 * Employment Density

The model results can be interpreted as follows:

- Every additional increase in household density of ten households per acre increases the percent of transit work trips to the station by 3%
- Every additional increase in employment density of 10 jobs per acre increases the percent of transit work trips to the station by 1%
- As the auto accessibility of the station increases, transit mode share for work trips decreases
- As the transit accessibility of the station increases, transit mode share for work trips increases

3.3.2 Station Area Non-Work Trip Mode Split Models

Using trip data from the BATS survey, mode share of non-work trips within ½ mile of each of the 146 rail stations in our study area were calculated. Only data for stations with at least 25 non-work trips within ½ mile of the station were used, for a total of 55 stations. Considering all non-work trips made to the station area, the percent of those trips made by car driver (either drive alone or carpool) was calculated and this value was used as the dependent variable for the car driver models. Similarly, the percent of non-work trips made by transit (rail, bus, or ferry), was calculated for each station area and used as the dependent variable for the transit models. The models can be used to estimate the percent of non-work trips to a station area that are made either by a car driver or by transit, based on various station area characteristics.

Data set: 55 rail stations with at least 25 non-work trips within ½ mile of the station.

3.3.2.1 Non-Work Trip Car Driver Mode Share Tobit Model

The variables in **Table 15** were entered into a Tobit Model analysis, run in R, in order to estimate the dependent variable: car driver mode share for non-work trips within ½ mile of a rail station. **Table 22** shows the model outputs.

Table 22: Non-Work Trip Car Driver Mode Share Tobit Model Results

Variable	Coefficient	Std. Error	t value
(Constant)	0.643	0.021	30.797
HH Density Hmi	-0.008	0.003	-2.542
Parking Cost	-0.163	0.047	-3.459

Non-Work Trip Car Driver Mode Share =

y_i = .643 - .008 * HH Density Hmi - .163 * Parking Cost +e_i

McKelvey-Zavoina Pseudo-R^2 = 0.439

3.3.2.2 Non-Work Trip Car Driver Mode Share OLS Model

The variables in **Table 15** were entered into an OLS regression analysis, run in SPSS, in order to estimate the dependent variable: car driver mode share (drivers only, not passengers) for non-work trips within ½ mile of a rail station. **Table 23** and **Table 24** show the model outputs for the goodness of fit statistics and the coefficients:

Table 23: Non-Work Trip Car Driver Mode Share OLS Model Goodness of Fit Statistics

R Square	Adjusted R Square	F Statistic
0.439	0.416	19.92

Table 24: Non-Work Trip Car Driver Mode Share OLS Model Results - Recommended Model						
Coefficients[a]						
		Unstandardized Coefficients		Standardized Coefficients		
Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	.643	.021		29.925	.000
	HHDensityHmi	-.008	.003	-.316	-2.493	.016
	ParkCost	-.163	.048	-.431	-3.396	.001

a. Dependent Variable: NWTDriver_HMi

Since we are predicting a proportion, we do not want the predicted value to be above 1. Therefore, the following equation should be applied:

Non-Work Trip Car Driver Mode Share =

y = .643 - .008 * Household Density - .163 * Parking Cost)

The model results can be interpreted as follows:

- Every additional increase in household density of one household per acre decreases the percent of driver non-work trips to the station by 1%
- As the average, hourly, long-term parking rate in the station area increases by $1, the percent of driver non-work trips to the station decreases by 16%

3.3.2.3 Non-Work Trip Car Mode Share Tobit Model

Since the R^2 values for car driver mode share were low, the same models were run for car mode share. The car driver mode share for non-work trips is lower than for work trips, while car passenger mode share is higher for non-work trips than for work trips. The variables in **Table 15** were entered into a Tobit Model analysis, run in R, in order to estimate the dependent variable: car mode share (driver or passenger) for non-work trips within ½ mile of a rail station. **Table 25** shows the model outputs.

Table 25: Non-Work Trip Car Mode Share Tobit Model Results			
Variable	Coefficient	Std. Error	t value
(Constant)	1.040	0.053	19.595
HH Density Hmi	-0.011	0.003	-4.043
Transit Access HMi	-0.019	0.009	-2.241
Parking Cost	-0.183	0.041	-4.440

Non-Work Trip Car Mode Share =

y_i = 1.040 - .011 * HH Density Hmi - .019 * Transit Access HMi - .183 * Parking Cost + e_i

McKelvey-Zavoina Pseudo-R^2 = 0.739

3.3.2.4 Non-Work Trip Car Mode Share OLS Model

The variables in **Table 15** were entered into an OLS regression analysis, run in SPSS, in order to estimate the dependent variable: car mode share (driver or passenger) for non-work trips within ½ mile of a rail station. **Table 26** and **Table 27** show the model outputs for the goodness of fit statistics and the coefficients.

Table 26: Non-Work Trip Car Mode Share OLS Model Goodness of Fit Statistics

R Square	Adjusted R Square	F Statistic
0.739	0.723	47.19

Table 27: Non-Work Trip Car Mode Share OLS Model Results – Recommended Model

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	1.040	.052		19.879	.000
	HH Density Hmi	-.011	.003	-.372	-3.908	.000
	Transit Access HMi	-.019	.008	-.225	-2.256	.028
	Parking Cost	-.183	.043	-.408	-4.252	.000

a. Dependent Variable: Non Work Trip Car Mode Share

Since we are predicting a proportion, we do not want the predicted value to be above 1. Therefore, the following equation should be applied:

Non-Work Trip Car Mode Share =

y = 1.040 - .011 * HH Density Hmi - .019 * Transit Access - .183 * Parking Cost

The model results can be interpreted as follows:

- Every additional increase in household density of one household per acre decreases the percent of car non-work trips to the station by 1%
- As transit accessibility increases, car mode share for non-work trips decreases
- As the average, hourly, long-term parking rate in the station area increases by $1, the percent of car non-work trips to the station decreases by 18%

3.3.2.5 Non-Work Trip Transit Mode Share Tobit Model

The variables in **Table 15** were entered into a Tobit Model analysis, run in R, in order to estimate the dependent variable: transit mode share for non-work trips within ½ mile of a rail station. **Table 28** shows the model outputs.

Table 28: Non-Work Trip Transit Mode Share Tobit Model Results

Variable	Coefficient	Std. Error	t value
(Constant)	-0.082	0.041	-2.014
Parking Cost	0.133	0.040	3.330
Transit Access Hmi	0.014	0.006	2.387
Ret Emp Density Hmi	0.003	0.003	1.314

Non-Work Trip Transit Mode Share =

y_i = -.082 + .133 * Parking Cost + .014 * Transit Access Hmi - .003 * Retail Employment Density $+e_i$

McKelvey-Zavoina Pseudo-R^2 = 0.739

3.3.2.6 Non-Work Trip Transit Mode Share OLS Model

The variables in **Table 15** were entered into an OLS regression analysis, run in SPSS, in order to estimate the dependent variable: transit mode share for non-work trips within ½ mile of a rail station. **Table 29** and **Table 30** show the model outputs for the goodness of fit statistics and the coefficients.

Table 29: Non-Work Trip Transit Mode Share OLS Model Goodness of Fit Statistics

R Square	Adjusted R Square	F Statistic
0.734	0.718	46.04

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Table 30: Non-Work Trip Transit Mode Share OLS Model Results – Recommended Model

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.046	.028		-1.640	.107
	Parking Cost	.127	.032	.522	4.018	.000
	Transit Access HMi	.011	.004	.237	2.564	.013
	Retail Emp Density Hmi	.004	.002	.203	1.735	.089

a. Dependent Variable: Non Work Trip Transit Mode Share

Since we are predicting a proportion, we do not want the predicted value to be below 0. Therefore, the following equation should be applied:

Non-Work Trip Transit Mode Share =

y = -.046 + .127 * Parking Cost + .011 * Transit Accessibility + .004 * Retail Employment Density

The model results can be interpreted as follows:

- As the average, hourly, long-term parking rate in the station area increases by $1, the percent of transit non-work trips to the station increases by 13%
- As transit accessibility increases, transit mode share for non-work trips increases
- Every additional increase in retail employment density of 10 retail jobs per acre increases the percent of transit non-work trips to the station area by 4%

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4.0 ESTIMATING TRIP MODE AND DISTANCE

Analysis was run on all trips with an origin or destination within ½ mile of a rail station. **Table 31** summarizes the variables collected for each trip including household characteristics of the person taking the trip.

Table 31: Trip Variables

Variable Name	Description	Source
Household Data		
Household Size	Number of persons in the household	BATS (2000)
Household Vehicles	Number of vehicles in the household	BATS (2000)
Owner	Binary variable indicating the household is owner occupied (0/1)	BATS (2000)
Low Income	Binary variable indicating the household income is less than $40,000 (0/1)	BATS (2000)
Rail Station Data		
O Rail Distance	Distance from trip origin to nearest rail station (miles)	Fehr & Peers (calculated in 2011 using stations that existed in 2000)
D Rail Distance	Distance from trip destination to nearest rail station (miles)	Fehr & Peers (calculated in 2011 using stations that existed in 2000)
O Parking Cost	Hourly parking rate paid by long-term parkers in the TAZ of the trip origin (2000 cents)	MTC (2000)
D Parking Cost	Hourly parking rate paid by long-term parkers in the TAZ of the trip destination (2000 cents)	MTC (2000)
Neighborhood Data		
O HH Density	Household density of TAZ of the trip origin (households per acre)	MTC (2000)
D HH Density	Household density of TAZ of the trip destination (households per acre)	MTC (2000)
O Emp Density	Employment density of TAZ of the trip origin (employees per acre)	MTC (2000)
D Emp Density	Employment density of TAZ of the trip destination (employees per acre)	MTC (2000)
O Ret Emp Density	Retail employment density of TAZ of the trip origin (employees per acre)	MTC (2000)
D Ret Emp Density	Retail employment density of TAZ of the trip destination (employees per acre)	MTC (2000)
O Diversity	Jobs/housing diversity indicator of TAZ of the trip origin	Fehr & Peers (calculated in 2011 using 2000 MTC data)
D Diversity	Jobs/housing diversity indicator of TAZ of the trip destination	Fehr & Peers (calculated in 2011 using 2000 MTC data)

Trip Data		
Trip Distance	Trip distance in miles	Fehr & Peers (calculated in 2011 using 2000 MTC data)
Work Trip	Binary variable indicating that the trip is a work trip (0/1)	BATS (2000)
Car Driver Trip	Binary variable indicating that the trip was made by car driver (0/1)	BATS (2000)

4.1 Estimating Driver Trips

A binary logistic regression was run on trips to estimate whether or not a trip was made by a car driver.

Dependent Variable: *Car Driver Trip (=1 if trip was made by car driver (drive alone or carpool), =0 if trip was made by a car passenger or another mode)*

4.1.1 Trips with a Destination Near a Rail Station

Data set: 21,750 trips with a destination within ½ mile of a rail station.

The following tables show the model outputs for the goodness of fit statistics and the coefficients:

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	25235.714[a]	.202	.270

Classification Table[a]

Observed			Predicted		
			CarDriver		Percentage Correct
			.00	1.00	
Step 1	CarDriver	.00	6727	4081	62.2
		1.00	2550	8392	76.7
	Overall Percentage				69.5

a. The cut value is .500

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Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	O Rail Distance	.017	.005	13.612	1	.000	1.018
	O HH Density	-.024	.002	142.451	1	.000	.976
	O Emp Density	-.002	.000	64.849	1	.000	.998
	D HH Density	-.017	.002	90.577	1	.000	.984
	Trip Distance	.009	.002	26.290	1	.000	1.009
	Household Size	-.193	.013	230.338	1	.000	.824
	Owner	.474	.034	197.048	1	.000	1.607
	Low Income	-.289	.048	35.579	1	.000	.749
	O Parking Cost	-.005	.001	75.553	1	.000	.995
	D Parking Cost	-.009	.000	1265.056	1	.000	.991
	Work Trips	.586	.033	309.211	1	.000	1.796
	Constant	.826	.053	238.523	1	.000	2.283

The model results can be interpreted as follows:

- As distance from trip origin to a rail station increases, the trip is more likely to be made by a car driver
- As both household and employment density near a trip origin increase, the trip is less likely to be made by a car driver
- As the household density near a trip destination increases, the trip is less likely to be made by a car driver
- As the trip distance increases the trip is more likely to be made by a car driver
- As the household size increases the trip is less likely to be made by a car driver
- Owner occupied households are more likely to make trips by a car driver
- Low income households are less likely to make trips by a car driver
- As the cost of parking at the trip origin or destination increases, the trip is less likely to be made by a car driver
- Work trips are more likely to be made by a car driver than non-work trips

4.1.2 Trips with an Origin Near a Rail Station

Data set: 21,517 trips with an origin within ½ mile of a rail station.

The following tables show the model outputs for the goodness of fit statistics and the coefficients:

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	24901.890[a]	.205	.273

Classification Table[a]

Observed			Predicted CarDriver .00	Predicted CarDriver 1.00	Percentage Correct
Step 1	CarDriver	.00	6785	4000	62.9
		1.00	2452	8280	77.2
	Overall Percentage				70.0

a. The cut value is .500

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	O HH Density	-.023	.002	161.144	1	.000	.977
	O Emp Density	-.001	.000	91.737	1	.000	.999
	D HH Density	-.020	.002	97.358	1	.000	.980
	D Emp Density	-.001	.000	31.147	1	.000	.999
	Trip Distance	.006	.002	12.417	1	.000	1.006
	Household Size	-.193	.013	225.784	1	.000	.825
	Owner	.468	.034	190.020	1	.000	1.597
	Low Income	-.305	.049	39.288	1	.000	.737
	O Parking Cost	-.006	.000	243.147	1	.000	.994
	D Parking Cost	-.006	.001	110.457	1	.000	.994
	Work Trips	.587	.034	303.472	1	.000	1.799
	D Rail Distance	.024	.005	24.442	1	.000	1.025
	Constant	.847	.054	248.928	1	.000	2.332

The results are very similar to those for trips with a destination within ½ mile of a rail station.

4.2 Estimating Trip Distance

OLS regressions were run on trips to estimate trip distance. Trip distance was calculated using TAZ centroid to centroid skim distance between trip origin and destination.

Dependent Variable: *Trip Distance (miles)*

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4.2.1 Trips with a Destination Near a Rail Station

Data set: 21,750 trips with a destination within ½ mile of a rail station.

The following tables show the model outputs for the goodness of fit statistics and the coefficients:

R Square	Adjusted R Square	F Statistic
0.400	0.400	1318.37

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	4.835	.240		20.147	.000
	Household Size	.080	.048	.009	1.651	.099
	Low Income	-.988	.181	-.030	-5.460	.000
	Work Trip	3.196	.125	.145	25.604	.000
	Car Driver	.630	.128	.029	4.936	.000
	O HH Density	-.113	.006	-.114	-18.020	.000
	O Emp Density	-.004	.000	-.069	-7.732	.000
	O Parking Cost	-.021	.002	-.108	-11.593	.000
	O Rail Distance	1.312	.014	.499	90.566	.000
	D HH Density	.042	.006	.043	6.880	.000
	D Diversity	-1.713	.270	-.046	-6.336	.000
	D Parking Cost	.014	.001	.094	12.565	.000

a. Dependent Variable: Trip distance

4.2.2 Car Driver Trips with a Destination Near a Rail Station – **Recommended Model**

Data set: 10,944 trips with a destination within ½ mile of a rail station made by a car driver.

The following tables show the model outputs for the goodness of fit statistics and the coefficients:

R Square	Adjusted R Square	F Statistic
0.349	0.349	733.351

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Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	5.452	.247		22.034	.000
	Low income	-.926	.293	-.025	-3.155	.002
	Work Trip	3.608	.183	.159	19.704	.000
	O HH Density	-.134	.012	-.095	-11.414	.000
	O Emp Density	-.006	.001	-.044	-5.574	.000
	O Rail Distance	1.292	.021	.487	60.177	.000
	D HH Density	.030	.011	.024	2.740	.006
	D Diversity	-1.482	.370	-.038	-4.004	.000
	D Parking Cost	.016	.002	.075	8.015	.000

a. Dependent Variable: Trip distance

4.2.3 Trips with an Origin Near a Rail Station

Data set: 21,518 trips with an origin within ½ mile of a rail station.

The following tables show the model outputs for the goodness of fit statistics and the coefficients:

R Square	Adjusted R Square	F Statistic
0.394	0.394	1273.12

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.522	.237		19.051	.000
	Household Size	.156	.048	.018	3.268	.001
	Low Income	-.942	.179	-.029	-5.269	.000
	Work Trip	3.343	.124	.156	26.958	.000
	Car Driver	.417	.126	.019	3.304	.001
	O HH Density	.050	.006	.052	8.294	.000

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
	O Diversity	-1.901	.267	-.053	-7.113	.000
	O Parking Cost	.013	.001	.086	11.335	.000
	D HH Density	-.108	.006	-.113	-17.796	.000
	D Emp Density	-.004	.000	-.074	-8.240	.000
	D Parking Cost	-.019	.002	-.102	-10.815	.000
	D Rail Distance	1.319	.015	.497	89.439	.000

a. Dependent Variable: Trip distance

4.2.4 Car Driver Trips with an Origin Near a Rail Station

Data set: 10,734 trips with an origin within ½ mile of a rail station made by a car driver.

The following tables show the model outputs for the goodness of fit statistics and the coefficients:

R Square	Adjusted R Square	F Statistic
0.350	0.350	723.215

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	4.879	.242		20.157	.000
	Low Income	-.915	.287	-.025	-3.194	.001
	Work Trip	3.762	.179	.171	21.027	.000
	O HH Density	.041	.011	.033	3.724	.000
	O Diversity	-1.427	.361	-.037	-3.951	.000
	O Parking Cost	.016	.002	.077	8.281	.000
	D HH Density	-.121	.011	-.093	-11.152	.000
	D Emp Density	-.006	.001	-.047	-5.925	.000
	D Rail Distance	1.304	.022	.487	59.940	.000

a. Dependent Variable: Trip distance

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5.0 ESTIMATING HOUSEHOLD VEHICLES

Since not all jurisdictions have good models to predict household vehicle ownership/availability, models were created to predict this variable. Household vehicle ownership was divided into five ordered categories (hhvehcat). This variable was used as the dependent variable in ordered logit and ordered probit models. The results are provided below. The pseudo R-square values for the logit model are slightly higher than those for the probit model.

Household Vehicle Model: Ordered Logit Parameter Estimates

Parameter Estimates

		Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Threshold	[hhvehcat = .00]	-2.798	.087	1034.559	1	.000	-2.968	-2.627
	[hhvehcat = 1.00]	1.055	.068	241.386	1	.000	.922	1.188
	[hhvehcat = 2.00]	4.056	.078	2669.446	1	.000	3.902	4.209
	[hhvehcat = 3.00]	6.006	.091	4336.585	1	.000	5.827	6.185
Location	Low income	-1.273	.049	680.600	1	.000	-1.369	-1.178
	HH SIZE	.568	.016	1227.312	1	.000	.537	.600
	Num workers	.804	.024	1169.404	1	.000	.758	.850
	Multi Family	-1.241	.043	833.504	1	.000	-1.325	-1.157
	Activity Density	-.020	.001	312.986	1	.000	-.022	-.018
	AutoTransitRatio	.749	.078	91.927	1	.000	.596	.902

Link function: Logit.

Household Vehicle Model: Ordered Logit Goodness of Fit Statistics

Goodness-of-Fit

	Chi-Square	df	Sig.
Pearson	253797.523	58366	.000
Deviance	28814.068	58366	1.000

Link function: Logit.

Pseudo R-Square

Cox and Snell	.463
Nagelkerke	.501
McFadden	.241

Link function: Logit.

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Household Vehicle Model: Ordered Probit Parameter Estimates

Parameter Estimates

		Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Threshold	[hhvehcat = .00]	-1.512	.045	1111.537	1	.000	-1.601	-1.423
	[hhvehcat = 1.00]	.589	.038	242.290	1	.000	.515	.663
	[hhvehcat = 2.00]	2.287	.042	2980.502	1	.000	2.205	2.369
	[hhvehcat = 3.00]	3.327	.047	4993.222	1	.000	3.234	3.419
Location	Low income	-.717	.027	715.168	1	.000	-.770	-.665
	HH SIZE	.309	.009	1163.765	1	.000	.291	.327
	Num workers	.432	.013	1081.207	1	.000	.406	.458
	Multi Family	-.719	.024	908.542	1	.000	-.766	-.673
	Activity Density	-.009	.001	250.195	1	.000	-.011	-.008
	AutoTransitRatio	.502	.044	132.975	1	.000	.417	.587

Link function: Probit.

Household Vehicle Model: Ordered Probit Goodness of Fit Statistics

Goodness-of-Fit

	Chi-Square	df	Sig.
Pearson	5.487E9	58366	.000
Deviance	29044.853	58366	1.000

Link function: Probit.

Pseudo R-Square

Cox and Snell	.455
Nagelkerke	.492
McFadden	.236

Link function: Probit.

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ATTACHMENT 4.1: Vehicle Trip Rate Models, Part 1

Regression Model 1a: All Households

Dependent Variable: Average daily (weekday) household car driver trips

Calculating dependent variable: BATS data were collected over a period of two days. Data were collected on all trips by persons in the household. Weekend trips were removed. Weekday trips made by a car driver (either drive alone or carpool) were aggregated to the household level. This two day sum of household trips was divided by 2 to get average daily household car driver trips.

Data set: 14,686 households from the BATS survey with weekday trip data.

The following tables show the model outputs for the goodness of fit statistics and the coefficients:

R Square	Adjusted R Square	F Statistic
0.244	0.243	591.79

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.221	.346		-.638	.523
	Household Size	.968	.020	.371	49.448	.000
	Low Income	-.862	.065	-.100	-13.245	.000
	Owner	.773	.055	.109	14.044	.000
	Activity Density HMi	-.010	.001	-.071	-6.906	.000
	Auto Access HMi	.210	.031	.072	6.775	.000
	Transit Access HMi	-.053	.017	-.045	-3.190	.001
	Trains Per Day	-.001	.000	-.054	-6.085	.000
	ln(Rail Distance)	.091	.026	.039	3.516	.000

a. Dependent Variable: DriverTrips

The model results can be interpreted as follows:

- Every additional person in the household increases the average daily vehicle trip rate of the household by 1
- As activity density increases by 100 per acre, average daily vehicle trip rate decreases by 1
- The average daily vehicle trip rate for low income households is 0.9 lower than for non low income households
- As accessibility by auto increases, vehicle trip rate increases
- As accessibility by transit increases, vehicle trip rate decreases

- As number of daily trains through the closest rail station increases by 100, average daily vehicle trip rate decreases by 0.1
- The average daily vehicle trip rate for owner occupied households is 0.8 higher than for renter occupied households
- As the natural log of the distance to the closest rail station increases by 10, the average daily vehicle trip rate for the household increases by .9

Regression Model 1b: All Households

This model includes the variable *Household Vehicles* and can be used if data for this variable is available. However, once this variable was added, *NMT Access* and *Trains per Day* were removed from the model since they were no longer significant.

Dependent Variable: *Average daily (weekday) household car driver trips*

Calculating dependent variable: BATS data were collected over a period of two days. Data were collected on all trips by persons in the household. Weekend trips were removed. Weekday trips made by a car driver (either drive alone or carpool) were aggregated to the household level. This two day sum of household trips was divided by 2 to get average daily household car driver trips.

Data set: 14,686 households from the BATS survey with weekday trip data.

The following tables show the model outputs for the goodness of fit statistics and the coefficients:

R Square	**Adjusted R Square**	**F Statistic**
0.296	0.295	770.844

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-1.359	.328		-4.139	.000
	Household Size	.672	.021	.257	32.100	.000
	Activity Density HMi	-.010	.001	-.067	-7.145	.000
	Low Income	-.411	.064	-.048	-6.426	.000
	Auto Access HMi	.201	.029	.069	6.847	.000
	Transit Access HMi	-.031	.016	-.026	-1.951	.051
	Owner	.407	.054	.058	7.511	.000
	ln(Rail Distance)	.084	.025	.036	3.380	.001
	Household Vehicles	1.002	.030	.293	33.508	.000

a. Dependent Variable: DriverTrips

Regression Model 1c: All Households

This model uses density and accessibility values for the TAZ in which the household is located. This model can be used if data for the area within ½ mile of a household is not available. The results are similar to Model 1a.

Dependent Variable: *Average daily (weekday) household car driver trips*

Calculating dependent variable: BATS data were collected over a period of two days. Data were collected on all trips by persons in the household. Weekend trips were removed. Weekday trips made by a car driver (either drive alone or carpool) were aggregated to the household level. This two day sum of household trips was divided by 2 to get average daily household car driver trips.

Data set: 14,686 households from the BATS survey with weekday trip data.

The following tables show the model outputs for the goodness of fit statistics and the coefficients:

R Square	Adjusted R Square	F Statistic
0.244	0.244	593.72

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	-1.807	.495		-3.653	.000
	Household Size	.974	.020	.373	49.742	.000
	Activity Density (TAZ)	-.007	.001	-.059	-6.426	.000
	Low Income	-.838	.065	-.097	-12.831	.000
	Auto Accessibility (TAZ)	.346	.044	.101	7.911	.000
	Transit Accessibility (TAZ)	-.071	.015	-.063	-4.803	.000
	Trains per Day	-.001	.000	-.065	-7.509	.000
	Owner	.787	.055	.111	14.331	.000
	ln(Rail Distance)	.138	.027	.059	5.136	.000

a. Dependent Variable: DriverTrips

The model results can be interpreted as follows:

- Every additional person in the household increases the average daily vehicle trip rate of the household by 1
- As activity density in a TAZ increases by 100 per acre, average daily vehicle trip rate decreases by 0.7
- The average daily vehicle trip rate for low income households is 0.8 lower than for non low income households
- As accessibility by auto increases, vehicle trip rate increases
- As accessibility by transit increases, vehicle trip rate decreases

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- As number of daily trains through the closest rail station increases by 100, average daily vehicle trip rate decreases by 0.1
- The average daily vehicle trip rate for owner occupied households is 0.8 higher than for renter occupied households
- As the natural log of the distance to the closest rail station increases by 10, the average daily vehicle trip rate for the household increases by 1.4

Regression Model 2a: Households within 1 Mile of a Rail Station

Dependent Variable: Average daily (weekday) household car driver trips

Data set: 2,760 households from the BATS survey that are within 1 mile walking distance of a rail station.

The following tables show the model outputs for the goodness of fit statistics and the coefficients:

R Square	**Adjusted R Square**	**F Statistic**
0.284	0.282	136.21

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	.091	.894		.102	.919
	Household Size	.901	.044	.350	20.681	.000
	Low Income	-.714	.119	-.102	-6.011	.000
	Owner	.745	.103	.126	7.208	.000
	Activity Density HMi	-.004	.002	-.056	-2.287	.022
	Auto Access HMi	.352	.088	.085	3.995	.000
	Transit Access HMi	-.172	.050	-.105	-3.448	.001
	NMT Access HMi	-.178	.079	-.069	-2.242	.025
	Trains Per Day	-.001	.000	-.081	-3.610	.000

a. Dependent Variable: DriverTrips

The model results can be interpreted as follows:

- Every additional person in the household increases the average daily vehicle trip rate of the household by .9
- As activity density increases by 100 per acre, average daily vehicle trip rate decreases by 0.4
- The average daily vehicle trip rate for low income households is 0.7 lower than for non low income households

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- As accessibility by auto increases, vehicle trip rate increases
- As accessibility by transit increases, vehicle trip rate decreases
- As NMT accessibility increases, vehicle trip rate decreases
- As number of daily trains through the closest rail station increases by 100, average daily vehicle trip rate decreases by 0.1
- The average daily vehicle trip rate for owner occupied households is about 0.7 higher than for renter occupied households

Regression Model 2b: Households within 1 Mile of a Rail Station

This model includes the variable *Household Vehicles* and can be used if data for this variable is available. However, once this variable was added, *NMT Access* and *ln(Rail Distance)* were removed from the model since they were no longer significant.

Dependent Variable: *Average daily (weekday) household car driver trips*

Data set: 2,760 households from the BATS survey that are within 1 mile walking distance of a rail station.

The following tables show the model outputs for the goodness of fit statistics and the coefficients:

R Square	Adjusted R Square	F Statistic
0.371	0.369	202.735

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.464	.835		-.555	.579
	Household Size	.498	.046	.194	10.883	.000
	Activity Density HMi	-.004	.001	-.058	-3.000	.003
	Low Income	-.189	.114	-.027	-1.654	.098
	Auto Access HMi	.178	.078	.043	2.299	.022
	Transit Access HMi	-.139	.041	-.085	-3.367	.001
	Trains per Day	.000	.000	-.037	-1.901	.057
	Owner	.343	.098	.058	3.495	.000
	Household Vehicles	1.225	.062	.389	19.669	.000

a. Dependent Variable: DriverTrips

Regression Model 2c: Households within 1 Mile of a Rail Station

This model uses density and accessibility values for the TAZ in which the household is located. This model can be used if data for the area within ½ mile of a household is not available. The results are similar to Model 2a.

Dependent Variable: *Average daily (weekday) household car driver trips*

Data set: 2,760 households from the BATS survey that are within 1 mile walking distance of a rail station.

The following tables show the model outputs for the goodness of fit statistics and the coefficients:

R Square	**Adjusted R Square**	**F Statistic**
0.279	0.277	151.73

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.129	1.573		.082	.935
	Household Size	.914	.044	.355	20.890	.000
	Activity Density (TAZ)	-.005	.001	-.077	-3.992	.000
	Low Income	-.720	.119	-.103	-6.030	.000
	Auto Accessibility (TAZ)	.245	.140	.039	1.745	.081
	Transit Accessibility (TAZ)	-.190	.040	-.120	-4.794	.000
	Trains per Day	-.001	.000	-.082	-4.052	.000
	Owner	.794	.102	.134	7.748	.000

a. Dependent Variable: DriverTrips

The model results can be interpreted as follows:

- Every additional person in the household increases the average daily vehicle trip rate of the household by about .9
- As activity density in a TAZ increases by 100 per acre, average daily vehicle trip rate decreases by 0.5
- The average daily vehicle trip rate for low income households is 0.7 lower than for non low income households
- As accessibility by auto increases, vehicle trip rate increases
- As accessibility by transit increases, vehicle trip rate decreases
- As number of daily trains through the closest rail station increases by 100, average daily vehicle trip rate decreases by 0.1
- The average daily vehicle trip rate for owner occupied households is 0.8 higher than for renter occupied households

Regression Model 3a: Households within ½ Mile of a Rail Station

Dependent Variable: Average daily (weekday) household car driver trips

Data set: 1,062 households from the BATS survey that are within ½ mile walking distance of a rail station.

The following tables show the model outputs for the goodness of fit statistics and the coefficients:

R Square	Adjusted R Square	F Statistic
0.246	0.243	69.02

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.442	.457		7.531	.000
	Household Size	.811	.071	.320	11.472	.000
	Activity Density HMi	-.006	.002	-.094	-2.798	.005
	Low Income	-.772	.180	-.120	-4.297	.000
	Transit Access HMi	-.249	.057	-.145	-4.338	.000
	Owner	.627	.153	.116	4.104	.000

a. Dependent Variable: DriverTrips

The model results can be interpreted as follows:

- Every additional person in the household increases the average daily vehicle trip rate of the household by .8
- As activity density increases by 100 per acre, average daily vehicle trip rate decreases by 0.6
- The average daily vehicle trip rate for low income households is 0.8 lower than for non low income households
- As transit accessibility increases, household vehicle trip rate decreases
- The average daily vehicle trip rate for owner occupied households is 0.6 higher than for renter occupied households

Regression Model 3b: Households within ½ Mile of a Rail Station

This model includes the variable *Household Vehicles* and can be used if data for this variable is available.

Dependent Variable: *Average daily (weekday) household car driver trips*

Data set: 1,062 households from the BATS survey that are within ½ mile walking distance of a rail station.

The following tables show the model outputs for the goodness of fit statistics and the coefficients:

R Square	Adjusted R Square	F Statistic
0.336	0.332	88.70

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Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	1.888	.449		4.208	.000
	Household Size	.425	.074	.168	5.748	.000
	Activity Density HMi	-.005	.002	-.076	-2.410	.016
	Low Income	-.269	.174	-.042	-1.543	.123
	Transit Access HMi	-.152	.054	-.089	-2.795	.005
	Owner	.195	.148	.036	1.319	.187
	Household Vehicles	1.188	.100	.384	11.884	.000

a. Dependent Variable: DriverTrips

Regression Model 3c: Households within ½ Mile of a Rail Station

This model uses density and accessibility values for the TAZ in which the household is located. This model can be used if data for the area within ½ mile of a household is not available. The results are similar to Model 3a.

Dependent Variable: *Average daily (weekday) household car driver trips*

Data set: 1,062 households from the BATS survey that are within ½ mile walking distance of a rail station.

The following tables show the model outputs for the goodness of fit statistics and the coefficients:

R Square	Adjusted R Square	F Statistic
0.241	0.237	66.93

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.467	.446		7.774	.000
	Household Size	.816	.071	.322	11.494	.000
	Activity Density	-.003	.001	-.077	-2.521	.012
	Low Income	-.795	.180	-.123	-4.407	.000
	Transit Accessibility (TAZ)	-.257	.051	-.153	-5.046	.000
	Owner	.615	.153	.114	4.007	.000

a. Dependent Variable: DriverTrips

The model results can be interpreted as follows:

- Every additional person in the household increases the average daily vehicle trip rate of the household by .8
- As activity density in a TAZ increases by 100 per acre, average daily vehicle trip rate decreases by 0.3
- The average daily vehicle trip rate for low income households is 0.8 lower than for non low income households
- As transit accessibility increases, household vehicle trip rate decreases
- The average daily vehicle trip rate for owner occupied households is about 0.6 higher than for renter occupied households

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ATTACHMENT 4.2: Vehicle Trip Rate Models, Part 2

Model 1: OLS regression with demographic variables

Dependent Variable: Total vehicle trips per household over a 2-day span

Model Outputs:

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.511[a]	.261	.260	5.62047

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	.434	.690		.629	.530
	Household size	1.860	.040	.356	46.906	.000
	Low income	-1.304	.131	-.076	-9.957	.000
	Owner	1.058	.122	.075	8.700	.000
	Activity Density	-.007	.003	-.026	-2.457	.014
	AutoAccess	.399	.061	.069	6.518	.000
	TransitAccess	-.114	.033	-.048	-3.478	.001
	TrainsPerDay	-.001	.000	-.048	-5.371	.000
	LN(RailDistance)	.144	.051	.031	2.815	.005
	ZeroCarHH	-4.494	.264	-.133	-17.035	.000
	MultiFamily Dwelling	-.753	.129	-.051	-5.836	.000

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Model 2: Negative binomial regression with demographic variables

Dependent Variable: Total vehicle trips per household over a 2-day span

Model Outputs:

Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval Lower	95% Wald Confidence Interval Upper	Hypothesis Test Wald Chi-Square	Hypothesis Test df	Hypothesis Test Sig.
(Intercept)	1.210	.1294	.956	1.464	87.357	1	.000
Household Size	.204	.0079	.189	.220	671.532	1	.000
Low Income	-.191	.0258	-.242	-.140	54.545	1	.000
Owner	.106	.0234	.060	.152	20.470	1	.000
Activity Density	-.003	.0007	-.005	-.002	24.396	1	.000
AutoAccess	.047	.0114	.024	.069	16.668	1	.000
TransitAccess	-.007	.0063	-.019	.006	1.159	1	.282
TrainsPerDay	.000	5.3795E-5	.000	-7.939E-5	11.804	1	.001
LN(RailDistance)	.017	.0098	-.003	.036	2.900	1	.089
ZeroCarHH	-2.787	.0884	-2.960	-2.614	994.259	1	.000
MultiFamily	-.109	.0249	-.158	-.060	19.059	1	.000
(Scale)	1[a]						
(Negative binomial)	1						

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Continuous Variable Information

		N	Minimum	Maximum	Mean	Std. Deviation
Dependent Variable	DTrips2Days	14685	.00	53.00	8.6978	6.53472
Covariate	Household size	14685	1	11	2.32	1.251
	Low income	14685	.00	1.00	.1752	.38016
	Owner	14685	.00	1.00	.6919	.46174
	Activity Density	14685	.01	447.15	16.9660	22.66770
	AutoAccess	14685	2.3600	13.0200	11.297926	1.1267134
	TransitAccess	14685	.0000	11.0500	4.370672	2.7641531
	TrainsPerDay	14685	0	800	154.84	213.715
	LN(RailDistance)	14685	-5.52	4.62	1.1107	1.39783
	ZeroCarHH	14685	0	1	.04	.194
	MultiFamily	14685	0	1	.27	.445

Goodness of Fit[b]

	Value	df	Value/df
Deviance	6916.884	14674	.471
Scaled Deviance	6916.884	14674	
Pearson Chi-Square	6881.876	14674	.469
Scaled Pearson Chi-Square	6881.876	14674	
Log Likelihood[a]	-45627.911		
Akaike's Information Criterion (AIC)	91277.823		
Finite Sample Corrected AIC (AICC)	91277.841		
Bayesian Information Criterion (BIC)	91361.363		
Consistent AIC (CAIC)	91372.363		

Omnibus Test[a]

Likelihood Ratio Chi-Square	df	Sig.
3270.639	10	.000

Model 3: OLS regression without demographic variables

Dependent Variable: Total vehicle trips per household over a 2-day span

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Model Outputs:

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.479[a]	.229	.229	5.73764

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.235	.693		-.340	.734
	Household size	1.983	.040	.380	49.920	.000
	Activity Density	-.020	.003	-.071	-6.799	.000
	AutoAccess	.526	.062	.091	8.444	.000
	TransitAccess	-.168	.033	-.071	-5.064	.000
	TrainsPerDay	-.002	.000	-.050	-5.560	.000
	LN(RailDistance)	.124	.052	.027	2.381	.017
	MultiFamily Dwelling	-1.580	.117	-.108	-13.454	.000

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Model 4: Negative binomial regression without demographic variables

Dependent Variable: Total vehicle trips per household over a 2-day span

Model Outputs:

Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	1.091	.1244	.847	1.335	76.935	1	.000
Household Size	.227	.0078	.212	.242	852.982	1	.000
Activity Density	-.006	.0006	-.008	-.005	109.009	1	.000
AutoAccess	.062	.0111	.040	.084	31.053	1	.000
TransitAccess	-.010	.0062	-.022	.003	2.399	1	.121
TrainsPerDay	.000	5.1931E-5	.000	.000	20.222	1	.000
LN(RailDistance)	.014	.0097	-.005	.033	2.233	1	.135
MultiFamily	-.213	.0219	-.256	-.170	94.947	1	.000
(Scale)	1[a]						
(Negative binomial)	1						

Continuous Variable Information

		N	Minimum	Maximum	Mean	Std. Deviation
Dependent Variable	DTrips2Days	14685	.00	53.00	8.6978	6.53472
Covariate	Household size	14685	1	11	2.32	1.251
	Activity Density	14685	.01	447.15	16.9660	22.66770
	AutoAccess	14685	2.3600	13.0200	11.297926	1.1267134
	TransitAccess	14685	.0000	11.0500	4.370672	2.7641531
	TrainsPerDay	14685	0	800	154.84	213.715
	LN(RailDistance)	14685	-5.52	4.62	1.1107	1.39783
	MultiFamily	14685	0	1	.27	.445

Goodness of Fit[b]

	Value	df	Value/df

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Deviance	8283.902	14677	.564
Scaled Deviance	8283.902	14677	
Pearson Chi-Square	6058.406	14677	.413
Scaled Pearson Chi-Square	6058.406	14677	
Log Likelihood[a]	-46311.420		
Akaike's Information Criterion (AIC)	92638.840		
Finite Sample Corrected AIC (AICC)	92638.850		
Bayesian Information Criterion (BIC)	92699.597		
Consistent AIC (CAIC)	92707.597		

Omnibus Test[a]

Likelihood Ratio Chi-Square	df	Sig.
1903.622	7	.000

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Model 5: OLS regression with demographic variables and distance based accessibility

Dependent Variable: Total vehicle trips per household over a 2-day span

Model Outputs:

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.511[a]	.261	.260	5.61997

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.897	.732		1.225	.221
	Household size	1.861	.040	.356	46.933	.000
	Low income	-1.291	.131	-.075	-9.841	.000
	Owner	1.045	.122	.074	8.572	.000
	Activity Density	-.007	.003	-.024	-2.250	.024
	AutoAccess	.394	.061	.068	6.421	.000
	TransitAccess	-.122	.033	-.051	-3.680	.000
	TrainsPerDay	-.001	.000	-.049	-5.489	.000
	LN(RailDistance)	.199	.059	.043	3.386	.001
	ZeroCarHH	-4.491	.264	-.133	-17.026	.000
	MultiFamily	-.769	.129	-.052	-5.948	.000
	Distance Based Access	-.010	.005	-.020	-1.900	.057

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Model 6: Negative binomial regression with demographic variables and distance based accessibility

Dependent Variable: Total vehicle trips per household over a 2-day span

Model Outputs:

Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	1.242	.1368	.973	1.510	82.339	1	.000
Household Size	.204	.0079	.189	.220	671.905	1	.000
Low Income	-.190	.0259	-.241	-.139	53.959	1	.000
Owner	.105	.0234	.059	.151	20.053	1	.000
Activity Density	-.003	.0007	-.005	-.002	23.357	1	.000
AutoAccess	.046	.0115	.024	.069	16.405	1	.000
TransitAccess	-.007	.0064	-.020	.005	1.328	1	.249
TrainsPerDay	.000	5.4001E-5	.000	-8.245E-5	12.158	1	.000
LN(RailDistance)	.021	.0114	-.001	.043	3.396	1	.065
ZeroCarHH	-2.786	.0884	-2.959	-2.613	993.830	1	.000
MultiFamily	-.110	.0250	-.159	-.061	19.367	1	.000
Dist Based Access	-.001	.0010	-.003	.001	.537	1	.464
(Scale)	1[a]						
(Negative binomial)	1						

Continuous Variable Information

		N	Minimum	Maximum	Mean	Std. Deviation
Dependent Variable	DTrips2Days	14685	.00	53.00	8.6978	6.53472
Covariate	Household size	14685	1	11	2.32	1.251
	Low income	14685	.00	1.00	.1752	.38016
	Owner	14685	.00	1.00	.6919	.46174
	Activity Density	14685	.01	447.15	16.9660	22.66770
	AutoAccess	14685	2.3600	13.0200	11.297926	1.1267134
	TransitAccess	14685	.0000	11.0500	4.370672	2.7641531
	TrainsPerDay	14685	0	800	154.84	213.715
	LN(RailDistance)	14685	-5.52	4.62	1.1107	1.39783

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Continuous Variable Information

	N	Minimum	Maximum	Mean	Std. Deviation
ZeroCarHH	14685	0	1	.04	.194
MultiFamily	14685	0	1	.27	.445
Distance Based Access	14685	6.511	109.612	42.93886	13.122878

Goodness of Fit[b]

	Value	df	Value/df
Deviance	6916.347	14673	.471
Scaled Deviance	6916.347	14673	
Pearson Chi-Square	6881.074	14673	.469
Scaled Pearson Chi-Square	6881.074	14673	
Log Likelihood[a]	-45627.643		
Akaike's Information Criterion (AIC)	91279.286		
Finite Sample Corrected AIC (AICC)	91279.307		
Bayesian Information Criterion (BIC)	91370.421		
Consistent AIC (CAIC)	91382.421		

Omnibus Test[a]

Likelihood Ratio Chi-Square	df	Sig.
3271.176	11	.000

a. Compares the fitted model against the intercept-only model.

Model 7: OLS regression without demographic variables and with distance based accessibility

Dependent Variable: Total vehicle trips per household over a 2-day span

Model Outputs:

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.480[a]	.230	.230	5.73539

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.640	.735		.870	.384
	Household size	1.984	.040	.380	49.952	.000
	Activity Density	-.019	.003	-.067	-6.373	.000
	AutoAccess	.513	.062	.089	8.236	.000
	TransitAccess	-.181	.033	-.077	-5.424	.000
	TrainsPerDay	-.002	.000	-.052	-5.799	.000
	LN(RailDistance)	.229	.060	.049	3.816	.000
	MultiFamily	-1.595	.117	-.109	-13.579	.000
	Distance Based Access	-.019	.005	-.037	-3.536	.000

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Model 8: Negative binomial regression without demographic variables and with distance based accessibility

Dependent Variable: Total vehicle trips per household over a 2-day span

Model Outputs:

Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	1.173	.1320	.915	1.432	79.002	1	.000
Household Size	.227	.0078	.212	.242	852.925	1	.000
Activity Density	-.006	.0006	-.008	-.005	103.827	1	.000
AutoAccess	.062	.0112	.040	.084	30.140	1	.000
TransitAccess	-.011	.0063	-.023	.001	3.086	1	.079
TrainsPerDay	.000	5.2091E-5	.000	.000	21.567	1	.000
LN(RailDistance)	.026	.0112	.004	.048	5.291	1	.021
MultiFamily	-.215	.0219	-.258	-.172	96.215	1	.000
Dist Based Access	-.002	.0010	-.004	-3.262E-5	3.973	1	.046
(Scale)	1[a]						
(Negative binomial)	1						

Continuous Variable Information

		N	Minimum	Maximum	Mean	Std. Deviation
Dependent Variable	DTrips2Days	14685	.00	53.00	8.6978	6.53472
Covariate	Household size	14685	1	11	2.32	1.251
	Activity Density	14685	.01	447.15	16.9660	22.66770
	AutoAccess	14685	2.3600	13.0200	11.297926	1.1267134
	TransitAccess	14685	.0000	11.0500	4.370672	2.7641531
	TrainsPerDay	14685	0	800	154.84	213.715
	LN(RailDistance)	14685	-5.52	4.62	1.1107	1.39783
	MultiFamily	14685	0	1	.27	.445
	Distance Based Access	14685	6.511	109.612	42.93886	13.122878

Goodness of Fit[b]

	Value	df	Value/df
Deviance	8279.938	14676	.564
Scaled Deviance	8279.938	14676	
Pearson Chi-Square	6051.901	14676	.412
Scaled Pearson Chi-Square	6051.901	14676	
Log Likelihood[a]	-46309.438		
Akaike's Information Criterion (AIC)	92636.877		
Finite Sample Corrected AIC (AICC)	92636.889		
Bayesian Information Criterion (BIC)	92705.228		
Consistent AIC (CAIC)	92714.228		

Omnibus Test[a]

Likelihood Ratio Chi-Square	df	Sig.
1907.585	8	.000

FEHR & PEERS

ATTACHMENT 4.3: Vehicle Trip Rate Models, Part 3

Model 1: OLS regression with MTC auto and transit access variables

Dependent Variable: Average daily vehicle trips per household

Model Outputs:

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.511[a]	.261	.260	2.8102

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	.217	.345		.629	.530
	Household size	.930	.020	.356	46.906	.000
	Low income	-.652	.065	-.076	-9.957	.000
	Owner	.529	.061	.075	8.700	.000
	Activity density	-.004	.001	-.026	-2.457	.014
	AutoAccess	.200	.031	.069	6.518	.000
	TransitAccess	-.057	.016	-.048	-3.478	.001
	TrainsPerDay	-.001	.000	-.048	-5.371	.000
	LN(RailDistance)	.072	.026	.031	2.815	.005
	ZeroCarHH	-2.247	.132	-.133	-17.035	.000
	MultiFamily	-.377	.065	-.051	-5.836	.000

a. Dependent Variable: DriverTrips

FEHR & PEERS

Model 2: OLS regression with Fehr&Peers TAZ based attractions accessibility variable

Dependent Variable: Average daily vehicle trips per household

Model Outputs:

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.509[a]	.259	.259	2.8135

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.909	.161		11.865	.000
	Household Size	.935	.020	.358	47.100	.000
	Low Income	-.670	.066	-.078	-10.225	.000
	Owner	.551	.061	.078	9.087	.000
	Activity Density	-.007	.002	-.050	-3.889	.000
	Atr Accessibility (TAZ)	.353	.128	.046	2.760	.006
	TrainsPerDay	-.001	.000	-.065	-7.345	.000
	LN(RailDistance)	.086	.026	.037	3.321	.001
	ZeroCarHH	-2.260	.132	-.134	-17.129	.000
	MultiFamily	-.390	.065	-.053	-6.022	.000

a. Dependent Variable: DriverTrips

FEHR & PEERS

Model 3: OLS regression with Fehr&Peers household based attractions accessibility variable

Dependent Variable: Average daily vehicle trips per household

Model Outputs:

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.509[a]	.259	.259	2.8135

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.901	.159		11.985	.000
	Household size	.935	.020	.358	47.102	.000
	Low income	-.672	.066	-.078	-10.260	.000
	Owner	.552	.061	.078	9.106	.000
	Activity Density	-.007	.002	-.050	-3.959	.000
	TrainsPerDay	-.001	.000	-.064	-7.313	.000
	LN(RailDistance)	.088	.026	.038	3.397	.001
	ZeroCarHH	-2.260	.132	-.134	-17.123	.000
	MultiFamily	-.385	.065	-.052	-5.952	.000
	Atr Accessibility (HH)	.361	.126	.047	2.874	.004

a. Dependent Variable: DriverTrips

FEHR & PEERS

Model 4: OLS regression with Fehr&Peers binary (0/1) high accessibility variable

Dependent Variable: Average daily vehicle trips per household

Model Outputs:

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.509[a]	.259	.258	2.8139

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.178	.104		20.987	.000
	Household size	.933	.020	.357	47.050	.000
	Activity Density	-.004	.001	-.029	-2.995	.003
	TrainsPerDay	-.001	.000	-.059	-6.822	.000
	LN(RailDistance)	.064	.024	.027	2.710	.007
	MultiFamily	-.377	.065	-.051	-5.840	.000
	AccessHigh	.122	.064	.018	1.895	.058
	Low income	-.683	.065	-.079	-10.439	.000
	Owner	.555	.061	.078	9.142	.000
	ZeroCarHH	-2.249	.132	-.133	-17.024	.000

a. Dependent Variable: DriverTrips

FEHR PEERS

Model 5: OLS regression with MTC auto and transit access variables and without demographic variables

Dependent Variable: Average daily vehicle trips per household

Model Outputs:

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.479[a]	.229	.229	2.8688

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.118	.346		-.340	.734
	Household size	.992	.020	.380	49.920	.000
	Activity Density	-.010	.001	-.071	-6.799	.000
	TrainsPerDay	-.001	.000	-.050	-5.560	.000
	LN(RailDistance)	.062	.026	.027	2.381	.017
	MultiFamily	-.790	.059	-.108	-13.454	.000
	AutoAccess	.263	.031	.091	8.444	.000
	TransitAccess	-.084	.017	-.071	-5.064	.000

a. Dependent Variable: DriverTrips

Model 6: OLS regression with Fehr&Peers TAZ based attractions accessibility variable and without demographic variables

Dependent Variable: Average daily vehicle trips per household

Model Outputs:

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.476[a]	.226	.226	2.8745

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.047	.152		13.489	.000
	Household size	1.001	.020	.383	50.332	.000
	Activity density	-.016	.002	-.108	-8.416	.000
	TrainsPerDay	-.001	.000	-.074	-8.253	.000
	LN(RailDistance)	.095	.027	.041	3.581	.000
	MultiFamily	-.828	.059	-.113	-14.071	.000
	Atr Accessibility (TAZ)	.501	.130	.066	3.842	.000

a. Dependent Variable: DriverTrips

Model 7: OLS regression with Fehr&Peers home based attractions accessibility variable and without demographic variables

Dependent Variable: Average daily vehicle trips per household

Model Outputs:

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.476[a]	.226	.226	2.8747

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.067	.149		13.834	.000
	Household size	1.001	.020	.383	50.321	.000
	Activity Density	-.015	.002	-.107	-8.396	.000
	TrainsPerDay	-.001	.000	-.073	-8.155	.000
	LN(RailDistance)	.094	.027	.040	3.527	.000
	MultiFamily	-.822	.059	-.112	-13.982	.000
	Atr Accessibility (HH)	.482	.128	.063	3.768	.000

a. Dependent Variable: DriverTrips

FEHR & PEERS

Model 8: OLS regression with Fehr&Peers binary (0/1) high accessibility variable and without demographic variables

Dependent Variable: Average daily vehicle trips per household

Model Outputs:

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.475[a]	.226	.226	2.8754

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.441	.087		28.106	.000
	Household size	.999	.020	.383	50.260	.000
	Activity Density	-.011	.001	-.078	-8.154	.000
	TrainsPerDay	-.001	.000	-.066	-7.489	.000
	LN(RailDistance)	.060	.024	.026	2.489	.013
	MultiFamily	-.813	.059	-.111	-13.855	.000
	AccessHigh	.157	.065	.024	2.401	.016

a. Dependent Variable: DriverTrips

FEHR PEERS

ATTACHMENT 4.4: VMT Models, Part 1

<u>Regression Model 1a: All Households</u>

Dependent Variable: Average daily weekday VMT per household

Calculating dependent variable: BATS survey data includes information about trip origin and destination locations. TAZ to TAZ skim distance estimates provided by MTC across the 2000 road network were used to estimate trip distance for each weekday trip by a car or carpool driver in the BATS survey. These car driver trip distances were then aggregated by household to get average daily weekday VMT per household.

Data set: 14,420 households from the BATS survey with weekday trip data and trip origin and destination data.

The following tables show the model outputs for the goodness of fit statistics and the coefficients:

R Square	Adjusted R Square	F Statistic
0.167	0.166	411

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	12.450	1.320		9.431	.000
	Household Size	6.166	.211	.232	29.219	.000
	Low Income	-12.893	.703	-.147	-18.328	.000
	Auto Transit Ratio HMi	20.556	1.363	.163	15.082	.000
	Owner	2.258	.596	.031	3.789	.000
	Diversity HMi	-5.386	1.183	-.035	-4.552	.000
	Distance to Rail	.100	.024	.039	4.227	.000
	Activity Density HMi	-.060	.014	-.040	-4.264	.000

a. Dependent Variable: DriverVMT

The model results can be interpreted as follows:

- Every additional person in the household increases the average daily weekday VMT per household by 6
- The average daily weekday VMT for low income households is 13 lower than for non low income households
- As the ratio of auto to transit accessibility increases, average daily weekday VMT per household increases
- The average daily weekday VMT for owner occupied households is 2.3 higher than for renter occupied households

- As the residential to employment diversity of the area increases, average daily weekday VMT per household decreases
- For every additional 10 miles a household is located from a rail station, the average daily weekday VMT for the household increases by 1
- As the Activity Density increases by 10, average daily weekday VMT per household decreases by .6

<u>Regression Model 1b: All Households</u>

This model includes the variable *Household Vehicles* and can be used if data for this variable is available.

Dependent Variable: *Average daily weekday VMT per household*

Calculating dependent variable: BATS survey data includes information about trip origin and destination locations. TAZ to TAZ skim distance estimates provided by MTC across the 2000 road network were used to estimate trip distance for each weekday trip by a car or carpool driver in the BATS survey. These car driver trip distances were then aggregated by household to get average daily weekday VMT per household.

Data set: 14,420 households from the BATS survey with weekday trip data and trip origin and destination data.

The following tables show the model outputs for the goodness of fit statistics and the coefficients:

R Square	Adjusted R Square	F Statistic
0.208	0.207	539.31

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	3.610	1.275		2.831	.005
	Household Size	3.484	.228	.131	15.276	.000
	Low Income	-8.803	.693	-.100	-12.712	.000
	Auto Transit Ratio HMi	17.421	1.328	.138	13.121	.000
	Diversity HMi	-4.889	1.151	-.032	-4.248	.000
	Distance to Rail	.103	.023	.041	4.465	.000
	Activity Density HMi	-.015	.014	-.010	-1.108	.268
	Household Vehicles	8.774	.319	.252	27.538	.000

a. Dependent Variable: DriverVMT

<u>Regression Model 1c: All Households</u>

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This model uses density and accessibility values for the TAZ in which the household is located. This model can be used if data for the area within ½ mile of a household is not available. The results are similar to those for Model 1a.

Dependent Variable: *Average daily weekday VMT per household*

Calculating dependent variable: BATS survey data includes information about trip origin and destination locations. TAZ to TAZ skim distance estimates provided by MTC across the 2000 road network were used to estimate trip distance for each weekday trip by a car or carpool driver in the BATS survey. These car driver trip distances were then aggregated by household to get average daily weekday VMT per household.

Data set: 14,420 households from the BATS survey with weekday trip data and trip origin and destination data.

The following tables show the model outputs for the goodness of fit statistics and the coefficients:

R Square	**Adjusted R Square**	**F Statistic**
0.165	0.165	356.34

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	12.293	1.154		10.652	.000
	Household Size	6.194	.211	.233	29.311	.000
	Low Income	-12.967	.704	-.148	-18.411	.000
	Auto Transit Ratio (TAZ)	17.714	1.197	.151	14.795	.000
	Owner	2.442	.597	.034	4.088	.000
	Diversity (TAZ)	-3.801	1.083	-.027	-3.510	.000
	Distance to Rail	.127	.023	.050	5.524	.000
	Household Density (TAZ)	-.178	.043	-.040	-4.179	.000
	Employment Density (TAZ)	-.040	.018	-.019	-2.224	.026

a. Dependent Variable: DriverVMT

The model results can be interpreted as follows:

- Every additional person in the household increases the average daily weekday VMT per household by 6
- The average daily weekday VMT for low income households is 13 lower than for non low income households
- As the ratio of auto to transit accessibility increases, average daily weekday VMT per household increases

- The average daily weekday VMT for owner occupied households is 2.4 higher than for renter occupied households
- As the residential to employment diversity of the area increases, average daily weekday VMT per household decreases
- For every additional 10 miles a household is located from a rail station, the average daily weekday VMT for the household increases by 1.3
- As the Household Density increases by 10 households per acre, average daily weekday VMT per household decreases by 1.8
- As the Employment Density increases by 10 employees per acre, average daily weekday VMT per household decreases by .4

Regression Model 1d: All Households

Model 1d includes the same independent variables as were found to be significant in Model 2a and 3a. The results are included here for comparison purposes.

Dependent Variable: *Average daily weekday VMT per household*

Calculating dependent variable: BATS survey data includes information about trip origin and destination locations. TAZ to TAZ skim distance estimates provided by MTC across the 2000 road network were used to estimate trip distance for each weekday trip by a car or carpool driver in the BATS survey. These car driver trip distances were then aggregated by household to get average daily weekday VMT per household.

Data set: 14,420 households from the BATS survey with weekday trip data and trip origin and destination data.

The following tables show the model outputs for the goodness of fit statistics and the coefficients:

R Square	**Adjusted R Square**	**F Statistic**
0.165	0.165	568.77

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	8.088	1.004		8.056	.000
	Household Size	6.212	.211	.234	29.481	.000
	Low Income	-12.650	.701	-.144	-18.038	.000
	Owner	2.382	.594	.033	4.009	.000
	Activity Density HMi	-.060	.014	-.040	-4.272	.000
	Auto Transit Ratio HMi	23.517	1.173	.186	20.048	.000

a. Dependent Variable: DriverVMT

The model results can be interpreted as follows:

- Every additional person in the household increases the average daily weekday VMT per household by 6
- The average daily weekday VMT for low income households is 13 lower than for non low income households
- The average daily weekday VMT for owner occupied households is 2.4 higher than for renter occupied households
- As the Activity Density increases by 10 per acre, average daily weekday VMT per household decreases by .6
- As the ratio of auto to transit accessibility increases, average daily weekday VMT per household increases

Regression Model 2a: Households within 1 Mile of a Rail Station

Dependent Variable: Average daily weekday VMT per household

Data set: 2,690 households from the BATS survey that are within 1 mile walking distance of a rail station, have weekday trip data and trip origin and destination data.

The following tables show the model outputs for the goodness of fit statistics and the coefficients:

R Square	Adjusted R Square	F Statistic
0.150	0.149	95.12

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	6.927	1.907		3.633	.000
	Household Size	4.972	.423	.219	11.762	.000
	Low Income	-9.483	1.153	-.153	-8.226	.000
	Auto Transit Ratio HMi	27.539	4.614	.125	5.968	.000
	Owner	3.441	.995	.066	3.457	.001
	Activity Density HMi	-.042	.015	-.060	-2.834	.005

a. Dependent Variable: DriverVMT

The model results can be interpreted as follows:

- Every additional person in the household increases the average daily weekday VMT per household by 5
- The average daily weekday VMT for low income households is 9.5 lower than for non low income households
- As the ratio of auto to transit accessibility increases, average daily weekday VMT per household increases
- The average daily weekday VMT for owner occupied households is 3.4 higher than for renter occupied households

- As the Activity Density increases by 10 per acre, average daily weekday VMT per household decreases by 0.4

<u>Regression Model 2b: Households within 1 Mile of a Rail Station</u>

This model includes the variable *Household Vehicles* and can be used if data for this variable is available.

Dependent Variable: *Average daily weekday VMT per household*

Data set: 2,690 households from the BATS survey that are within 1 mile walking distance of a rail station, have weekday trip data and trip origin and destination data.

The following tables show the model outputs for the goodness of fit statistics and the coefficients:

R Square	**Adjusted R Square**	**F Statistic**
0.215	0.213	147.21

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	1.883	1.834		1.027	.305
	Household Size	1.850	.457	.081	4.045	.000
	Low Income	-5.621	1.126	-.091	-4.992	.000
	Auto Transit Ratio HMi	18.806	4.473	.085	4.204	.000
	Activity Density HMi	-.019	.014	-.027	-1.350	.177
	Household Vehicles	9.252	.604	.333	15.305	.000

a. Dependent Variable: DriverVMT

<u>Regression Model 2c: Households within 1 Mile of a Rail Station</u>

This model uses density and accessibility values for the TAZ in which the household is located. This model can be used if data for the area within ½ mile of a household is not available. The results are similar to those for Model 2a.

Dependent Variable: *Average daily weekday VMT per household*

Data set: 2,690 households from the BATS survey that are within 1 mile walking distance of a rail station, have weekday trip data and trip origin and destination data.

The following tables show the model outputs for the goodness of fit statistics and the coefficients:

R Square	**Adjusted R Square**	**F Statistic**
0.151	0.149	79.61

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	8.633	1.795		4.809	.000
	Household Size	4.955	.423	.218	11.702	.000
	Low Income	-9.656	1.154	-.156	-8.370	.000
	Auto Transit Ratio (TAZ)	23.099	4.018	.117	5.748	.000
	Owner	3.237	1.003	.062	3.226	.001
	Household Density (TAZ)	-.114	.045	-.053	-2.524	.012
	Employment Density (TAZ)	-.033	.015	-.041	-2.182	.029

a. Dependent Variable: DriverVMT

The model results can be interpreted as follows:

- Every additional person in the household increases the average daily weekday VMT per household by 5
- The average daily weekday VMT for low income households is 9.7 lower than for non low income households
- As the ratio of auto to transit accessibility increases, average daily weekday VMT per household increases
- The average daily weekday VMT for owner occupied households is 3.2 higher than for renter occupied households
- As the Household Density increases by 10 households per acre, average daily weekday VMT per household decreases by 1.1
- As the Employment Density increases by 10 employees per acre, average daily weekday VMT per household decreases by .3

Regression Model 3a: Households within ½ Mile of a Rail Station

Dependent Variable: Average daily weekday VMT per household

Data set: 1,023 households from the BATS survey that are within ½ mile walking distance of a rail station, have weekday trip data and trip origin and destination data.

The following tables show the model outputs for the goodness of fit statistics and the coefficients:

R Square	Adjusted R Square	F Statistic
0.138	0.134	32.64

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	7.638	3.179		2.402	.016
	Household Size	4.693	.723	.197	6.492	.000
	Low Income	-9.965	1.833	-.165	-5.438	.000
	Auto Transit Ratio HMi	27.118	9.416	.099	2.880	.004
	Owner	4.254	1.562	.084	2.723	.007
	Activity Density HMi	-.041	.022	-.067	-1.915	.056

a. Dependent Variable: DriverVMT

The model results can be interpreted as follows:

- Every additional person in the household increases the average daily weekday VMT per household by about 4.7
- The average daily weekday VMT for low income households is 10 lower than for non low income households
- As the ratio of auto to transit accessibility increases, average daily weekday VMT per household increases
- The average daily weekday VMT for owner occupied households is about 4.3 higher than for renter occupied households
- As the Activity Density increases by 10 per acre, average daily weekday VMT per household decreases by 0.4

Regression Model 3b: Households within ½ Mile of a Rail Station

This model includes the variable *Household Vehicles* and can be used if data for this variable is available.

Dependent Variable: *Average daily weekday VMT per household*

Data set: 1,023 households from the BATS survey that are within ½ mile walking distance of a rail station, have weekday trip data and trip origin and destination data.

The following tables show the model outputs for the goodness of fit statistics and the coefficients:

R Square	Adjusted R Square	F Statistic
0.206	0.202	52.70

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.113	3.026		1.359	.174
	Household Size	1.550	.772	.065	2.008	.045
	Low Income	-5.787	1.804	-.096	-3.207	.001
	Auto Transit Ratio HMi	13.371	9.152	.049	1.461	.144
	Activity Density HMi	-.028	.021	-.045	-1.344	.179
	Household Vehicles	9.940	1.023	.342	9.720	.000

a. Dependent Variable: DriverVMT

Regression Model 3c: Households within ½ Mile of a Rail Station

This model uses density and accessibility values for the TAZ in which the household is located. This model can be used if data for the area within ½ mile of a household is not available. The results are similar to those for Model 3a.

Dependent Variable: *Average daily weekday VMT per household*

Data set: 1,023 households from the BATS survey that are within ½ mile walking distance of a rail station, have weekday trip data and trip origin and destination data.

The following tables show the model outputs for the goodness of fit statistics and the coefficients:

R Square	Adjusted R Square	F Statistic
0.141	0.136	27.74

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Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	12.989	3.209		4.048	.000
	Household Size	4.651	.723	.195	6.435	.000
	Low Income	-10.125	1.830	-.168	-5.533	.000
	Auto Transit Ratio (TAZ)	13.558	8.393	.056	1.615	.107
	Owner	3.609	1.584	.071	2.278	.023
	Household Density (TAZ)	-.230	.081	-.100	-2.858	.004
	Employment Density (TAZ)	-.028	.016	-.052	-1.713	.087

a. Dependent Variable: DriverVMT

The model results can be interpreted as follows:

- Every additional person in the household increases the average daily weekday VMT per household by 4.6
- The average daily weekday VMT for low income households is 10 lower than for non low income households
- As the ratio of auto to transit accessibility increases, average daily weekday VMT per household increases
- The average daily weekday VMT for owner occupied households is 3.6 higher than for renter occupied households
- As the Household Density increases by 10 households per acre, average daily weekday VMT per household decreases by 2.3
- As the Employment Density increases by 10 employees per acre, average daily weekday VMT per household decreases by .3

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ATTACHMENT 4.5: VMT Models, Part 2

Model 1: OLS regression model with all 14,420 households used as inputs, number of vehicles per household included as an independent variable

Dependent Variable: Average daily household VMT

Model Outputs:

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.456[a]	.208	.207	29.601967

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	4.229	1.322		3.199	.001
	Household size	3.474	.228	.131	15.227	.000
	Low income:	-8.992	.701	-.102	-12.835	.000
	Auto Transit Ratio	17.639	1.333	.140	13.230	.000
	Owner	-1.054	.594	-.015	-1.776	.076
	Diversity	-5.042	1.154	-.033	-4.369	.000
	Distance to Rail	.102	.023	.040	4.415	.000
	Activity Density	-.018	.014	-.012	-1.328	.184
	Household vehicles	8.892	.325	.255	27.322	.000

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Model 2: OLS regression model with all 14,420 households used as inputs, a binary variable representing zero-car households included as an independent variable

Dependent Variable: Average daily household VMT

Model Outputs:

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.415[a]	.172	.172	30.254693

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	12.554	1.316		9.542	.000
	Household size	6.071	.211	.229	28.836	.000
	Low income	-11.552	.714	-.132	-16.185	.000
	Auto Transit Ratio	20.969	1.359	.166	15.430	.000
	Owner	1.697	.596	.024	2.845	.004
	Diversity	-5.493	1.179	-.036	-4.657	.000
	Distance to Rail	.099	.024	.039	4.220	.000
	Activity Density	-.018	.015	-.012	-1.257	.209
	ZeroCarHH	-14.302	1.432	-.084	-9.987	.000

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Model 3: OLS regression model with all 14,420 households used as inputs, no vehicle-related independent variables included

Dependent Variable: Average daily household VMT

Model Outputs:

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.408[a]	.167	.166	30.358202

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	12.450	1.320		9.431	.000
	Household size	6.166	.211	.232	29.219	.000
	Low income	-12.893	.703	-.147	-18.328	.000
	Auto Transit Ratio	20.556	1.363	.163	15.082	.000
	Owner	2.258	.596	.031	3.789	.000
	Diversity	-5.386	1.183	-.035	-4.552	.000
	Distance to Rail	.100	.024	.039	4.227	.000
	Activity Density	-.060	.014	-.040	-4.264	.000

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Model 4: 13,852 households with at least one car used as inputs, no vehicle-related independent variables included

Dependent Variable: Average daily household VMT

Model Outputs:

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.378[a]	.143	.143	30.794483

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	13.378	1.410		9.487	.000
	Household size	6.112	.217	.230	28.219	.000
	Low income:	-12.250	.754	-.133	-16.242	.000
	Auto Transit Ratio	20.269	1.449	.159	13.984	.000
	Owner	1.574	.618	.021	2.549	.011
	Diversity	-5.548	1.229	-.036	-4.514	.000
	Distance to Rail	.106	.024	.042	4.378	.000
	Activity Density	-.044	.019	-.023	-2.308	.021

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Model 5: 568 households with zero cars used as inputs, no vehicle-related independent variables included

Dependent Variable: Average daily household VMT

Model Outputs:

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.178[a]	.032	.019	5.948041

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-1.392	1.282		-1.086	.278
	Household size	1.086	.305	.150	3.565	.000
	Low income	-.468	.533	-.038	-.878	.380
	Auto Transit Ratio	2.373	2.131	.073	1.114	.266
	Owner	-.088	.689	-.006	-.128	.898
	Diversity	.955	1.118	.036	.854	.393
	Distance to Rail	-.023	.036	-.036	-.640	.522
	Activity Density	-.002	.005	-.016	-.320	.749

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ATTACHMENT 4.6: VMT Models, Part 3

Model 1: OLS regression with MTC auto and transit access variables

Dependent Variable: Average daily VMT per household

Model Outputs:

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.456[a]	.208	.207	29.601967

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	4.229	1.322		3.199	.001
	Household size	3.474	.228	.131	15.227	.000
	Activity Density	-.018	.014	-.012	-1.328	.184
	Low income	-8.992	.701	-.102	-12.835	.000
	Owner	-1.054	.594	-.015	-1.776	.076
	Auto Transit Ratio	17.639	1.333	.140	13.230	.000
	Diversity	-5.042	1.154	-.033	-4.369	.000
	Distance to rail	.102	.023	.040	4.415	.000
	Household vehicles	8.892	.325	.255	27.322	.000

a. Dependent Variable: DriverVMT

Model 2: OLS regression with Fehr&Peers TAZ based attractions accessibility variable

Dependent Variable: Average daily VMT per household

Model Outputs:

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.459[a]	.211	.210	29.546989

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	17.866	2.268		7.878	.000
	Household size	3.391	.228	.128	14.871	.000
	Activity density	.097	.021	.065	4.656	.000
	Low income	-9.432	.702	-.108	-13.439	.000
	Owner	-1.122	.593	-.016	-1.893	.058
	Auto Transit Ratio	11.913	1.540	.094	7.737	.000
	Diversity	-3.927	1.162	-.026	-3.381	.001
	Distance to rail	-.001	.027	.000	-.043	.966
	Household vehicles	8.805	.325	.253	27.088	.000
	Atr Accessibility (TAZ)	-11.298	1.528	-.144	-7.393	.000

a. Dependent Variable: DriverVMT

Model 3: OLS regression with Fehr&Peers households based attractions accessibility variable

Dependent Variable: Average daily VMT per household

Model Outputs:

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.459[a]	.210	.210	29.557724

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	15.806	2.181		7.246	.000
	Household size	3.412	.228	.129	14.967	.000
	Activity Density	.082	.021	.055	4.017	.000
	Low income	-9.316	.701	-.106	-13.286	.000
	Owner	-1.077	.593	-.015	-1.817	.069
	Auto Transit Ratio	12.790	1.517	.101	8.432	.000
	Diversity	-3.962	1.164	-.026	-3.405	.001
	Distance to rail	.011	.027	.004	.413	.679
	Household vehicles	8.840	.325	.254	27.195	.000
	Atr Accessibility (HH)	-9.890	1.484	-.125	-6.664	.000

a. Dependent Variable: DriverVMT

Model 4: OLS regression with Fehr&Peers binary (0/1) high accessibility variable

Dependent Variable: Average daily VMT per household

Model Outputs:

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.457[a]	.209	.209	29.579755

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	8.048	1.546		5.207	.000
	Household size	3.454	.228	.130	15.149	.000
	Activity Density	-.015	.014	-.010	-1.056	.291
	AccessHigh	-3.427	.720	-.051	-4.759	.000
	Low income	-9.052	.700	-.103	-12.927	.000
	Owner	-1.107	.593	-.015	-1.866	.062
	Auto Transit Ratio	14.175	1.518	.112	9.337	.000
	Diversity	-4.875	1.154	-.032	-4.226	.000
	Distance to rail	.072	.024	.028	3.023	.003
	Household vehicles	8.908	.325	.256	27.392	.000

a. Dependent Variable: DriverVMT

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ATTACHMENT 4.7: Alternative VMT Regression Analysis

Regression Model 1

Dependent Variable: Average daily VMT per household

Calculating dependent variable: BATS survey participants were asked to give the odometer reading of each household vehicle at the beginning of the first day of the survey and at the end of the second day of the survey. The difference between these two was calculated and divided by two and aggregated to the household level to get the average daily VMT per household. Some of the data were cleaned manually to reduce apparent data entry errors. However, even after data cleaning, concerns about the validity of the data remain.

Data set: 15,064 households from the BATS survey.

The following tables show the model outputs for the goodness of fit statistics and the coefficients:

R Square	Adjusted R Square	F Statistic
0.087	0.087	217.701

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	7.378	2.195		3.362	.001
	Household Size	7.393	.705	.108	10.488	.000
	Distance to Rail (miles)	.254	.058	.040	4.420	.000
	Household Vehicles	19.764	.979	.211	20.187	.000
	Urban Density	-.066	.039	-.016	-1.669	.095
	Trains per Day	-.010	.004	-.024	-2.517	.012

a. Dependent Variable: Average daily VMT for household

The model results can be interpreted as follows:

- Every additional person in the household increases the average daily VMT per household by 7.4
- For every additional 10 miles a household is located from a rail station, the average daily VMT for the household increases by 2.5
- Every additional vehicle owned by the household increases the average daily VMT for the household by 19.8
- As the combined density of residents and employment increases, VMT decreases
- As the number of trains per day at the closest rail station increases by 10, daily VMT for the household decreases by 0.1

Regression Model 2

Dependent Variable: Average daily VMT per household

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Data set: 1,091 households from the BATS survey that are within ½ mile walking distance of a rail station.

The following tables show the model outputs for the goodness of fit statistics and the coefficients:

R Square	Adjusted R Square	F Statistic
0.086	0.081	16.705

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	-93.083	121.665		-.765	.444
	Household Size	4.352	3.309	.054	1.315	.189
	Household Vehicles	22.350	4.921	.186	4.542	.000
	Auto Accessibility	16.467	11.124	.075	1.480	.139
	Transit Accessibility	-12.642	2.859	-.223	-4.421	.000

a. Dependent Variable: Average daily VMT for household

The model results can be interpreted as follows:

- Every additional person in the household increases the average daily VMT per household by 4.4
- Every additional vehicle owned by the household increases the average daily VMT for the household by 22.4
- As auto accessibility increases, VMT increases
- As transit accessibility increases, VMT decreases

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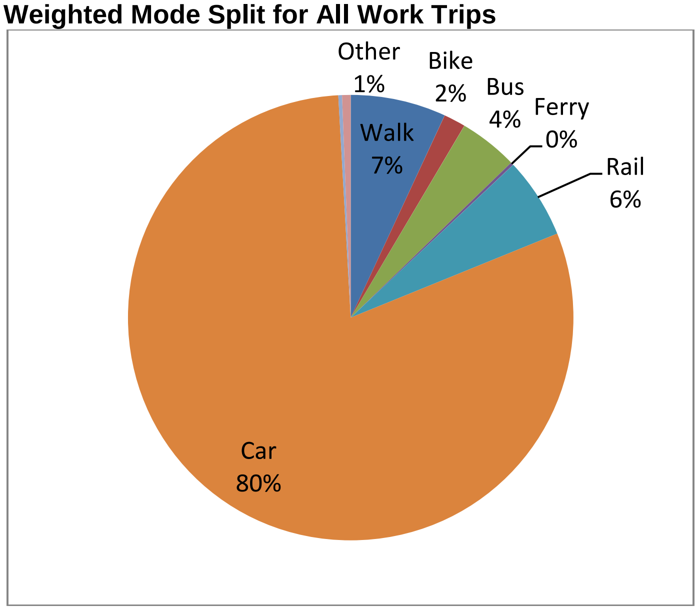
ATTACHMENT 4.8: Weighted Work Trip Mode Split Analysis

MTC created weights for the BATS survey data. The household weighting factor used geography of residence (PUMA of residence), household size, vehicles in household and tenure. An iterative proportional fitting (IPF) was performed with a method of successive averages (MSA). This procedure was run for sixteen iterations in order to create the household weighting variable HHWGT. The weighted sample expansion was found to be in line with Census 2000 values. However, it was found that "White, not Hispanic/Latino" heads of household were oversampled. A race correction factor was multiplied by HHWGT to create HHWGT2.

Next a person correction factor was created to account for the under-representation of household population. This was multiplied by HHWGT2 to get PFACTOR5. This person correction factor is to be applied to person, trip and activity files, but not to household or vehicle files. PFACTOR5 ranges from a 1.14 to 4589.1 with an average of 191.5.

The work trips were weighted by PFACTOR5 and mode split by station type were recalculated. The results are shown in the tables below. The car mode share is generally lower in the weighted results than in the unweighted results.

Weighted Mode Split for All Work Trips



	Weighted trips with a work trip end within ½ mile of:						
	Any Rail Station	**SF Muni Station**	**BART Station**	**VTA Station**	**Caltrain Station**	**Amtrak Station**	**ACE Station**
Walk	15%	22%	16%	3%	8%	17%	6%
Bike	2%	2%	2%	1%	0%	1%	0%
Bus	9%	15%	9%	1%	2%	0%	1%
Ferry	1%	2%	0%	0%	0%	3%	0%
Rail	17%	26%	18%	5%	4%	4%	0%
Car	56%	32%	54%	90%	85%	75%	92%
Other	0%	1%	1%	0%	1%	0%	1%

	Weighted trips with a work trip end within ¼ mile of:						
	Any Rail Station	**SF Muni Station**	**BART Station**	**VTA Station**	**Caltrain Station**	**Amtrak Station**	**ACE Station**
Walk	18%	22%	21%	4%	9%	10%	10%
Bike	2%	2%	3%	1%	0%	0%	0%
Bus	11%	15%	11%	1%	1%	0%	1%
Ferry	1%	1%	0%	0%	0%	0%	0%
Rail	21%	28%	22%	3%	8%	3%	0%
Car	46%	30%	42%	90%	81%	87%	88%
Other	1%	2%	1%	1%	1%	0%	1%