Detailed Methods

14TH AND HARVARD
Photo by Mr. T in DC

Customizing the H+T Index for the Greater DC Area

This project utilized the H+T Index developed by CNT, and customized and recalibrated it to estimate housing and transportation costs in the Washington, DC metropolitan area. Calculations were done at the block group level using 2006–2008 American Community Survey (ACS) Public Use Microdata Area (PUMA) data in conjunction with 2000 US Census data.

Local Data

CNT's original H+T Index was developed to utilize nationally available datasets with the intention of covering metropolitan areas across the county. However, in previous work focusing on one area, it has been found that the addition of detailed local datasets as independent variables can help improve the fit, and therefore accuracy, of the regression analyses. To further expand existing H+T work in the DC region, the regression analyses were refined through the use of detailed datasets (described below) obtained from local agencies and organizations, along with national datasets, to serve as independent variables in the customized transportation model. Specifically, detailed land use data were incorporated, both to refine the measurement of residential density as well as to create a land-use diversity measure; more robust measures of transit access were also tested and incorporated.

Updated Data

The H+T Index has so far been developed to calculate combined housing and transportation costs using primarily 2000 US Census data. The data required to calculate H+T costs at the neighborhood level is currently only available at the Census block group level for the year 2000. The ACS data, while available in more recent years, is currently not available at the block group level. Therefore, a combination of the block group-level 2000 Census data and the 2006–2008 ACS data at the PUMA level was utilized.

To preserve the block group level analysis with the best available current data at the PUMA level, a constant-share ratio extrapolation method was utilized. Smith, Tayman and Swanson explain that "the smaller area's share of the larger area's population is held constant at some historical level. . . . A projection of the smaller area can then be made by applying this share to the projection of the larger area" (2002, p.177).[18] Specifically, variables at the PUMA level were assumed to maintain the same block group composition between 2000 and 2006–2008. In other words, if the population in a block group made up 5% of the population of the PUMA in 2000, it was assumed that the population of the same block group made up 5% of the population of the same PUMA in 2006–2008. Algebraically, this is equivalent to calculating the percent change for each PUMA between 2000 and 2006–2008 and multiplying each 2000 block group by the appropriate PUMA percent change to estimate the 2006–2008 value.

Market Rate Housing Costs

Another significant aspect to the customization of the Index was the incorporation of market rate housing costs. The original Index utilizes Selected Monthly Owner Costs and Gross Rent, both from the US Census, to estimate housing costs. However, because Selected Monthly Owner Costs represent the average costs for all households with a mortgage, regardless of the age of the mortgage, these values can diminish recent housing trends.

To capture more recent trends in the housing market, multiple listing service (MLS) sales data were utilized to calculate average ownership costs for each census tract for which data were available.

Updated values (using the 2000 Census and the 2006–2008 ACS) for Gross Rent were utilized to capture renting costs.

RENTER COSTS

American Community Survey 3-Year Estimates 2006–2008:

Gross Rent—Universe: Renter-occupied housing units; used to define count of renter-occupied housing units with cash rent.

Aggregate Gross Rent—Universe: Renter-occupied housing units paying cash rent

Average gross rent is calculated for every PUMA necessary to cover the study area. Seven PUMAs had no data available for Gross Rent, and therefore no count of renter-occupied housing units paying cash rent, even though an aggregate value was available in Aggregate Gross Rent. Therefore, a weighted average ratio of renter-occupied housing units with cash rent to total renter-occupied housing units was obtained by state from the PUMAs for which the data were available. This ratio was then applied in the seven PUMAs without data to estimate the count of renter-occupied housing units paying cash rent from the total count of renter-occupied housing units.

Census 2000 SF3:

Gross Rent—Universe: Specified renter-occupied housing units; used to define count of specified renter-occupied housing units with cash rent.

Aggregate Gross Rent—Universe: Specified renter-occupied housing units paying cash rent

Average gross rent was calculated for every block group necessary to have equal coverage to the PUMAs utilized. These block group level values were then aggregated through weighted averages to the PUMA geographies.

PUMA level values for Average Gross Rent 2000 and Average Gross Rent 2006–2008 were then compared and percent changes were calculated for each PUMA. Every block group was then assigned a percent change value from the PUMA it is contained within, and the Average Gross Rent 2000 values were scaled up to 2006–2008 using this change.

18. Smith, Tayman and Swanson. 2002. *State and Local Population Projections: Methodology and Analysis.* Kluwer Academic/ Plenum Publishers, New York.

OWNERSHIP COSTS

Ownership costs were estimated using MLS sales data, both for average monthly mortgage payments and property tax payments. First, sales point data were geocoded and located in Census tracts, and tracts were filtered requiring a minimum sample size of five sales in the 2006–2008 time period (as to be consistent with the transportation model). Average sale prices were calculated for every Census tract that met this criterion. Average sales prices were converted to monthly mortgage payments by assuming a 20% down payment and 6% interest rate. Because property tax data had more limited availability, monthly property taxes and average home prices were compared at the jurisdiction level to estimate the tax rate. This rate was then applied to the individual Census tract average home prices to calculate the average property tax payments. Average monthly mortgage payments were summed with average property taxes, and each block group was estimated to have the average monthly ownership costs of the tract containing it.

WEIGHTED AVERAGE HOUSING COSTS

Using the ownership and renter costs detailed above, weighted average housing costs were calculated for each Census block group as:

$$\frac{(\text{Avg. Costs}_{\text{Owners}} \times \text{Owners}_{\text{Occupied Housing Units}}) + (\text{Avg. Costs}_{\text{Renters}} \times \text{Renters}_{\text{Occupied Housing Units}})}{\text{Owners}_{\text{Occupied Housing Units}} + \text{Renters}_{\text{Occupied Housing Units}}}$$

Transportation Model Development

General Structure

Household transportation costs, while defined in many different ways, are typically composed of auto ownership costs, auto usage costs, and public transit costs. The Bureau of Labor Statistics, in their Consumer Expenditure Survey Annual Expenditure tables, present total transportation costs as composed of vehicle purchases, gasoline, motor oil, finance charges, maintenance, repairs, insurance, rentals, leases, licenses and other charges, and public transportation. In their annual *Your Driving Costs* reports, AAA uses a proprietary methodological process to compile the annual cost of auto ownership. Their ownership costs are composed of fuel, maintenance, tires, insurance, license, registration and taxes, depreciation, and finance charges. The Federal Highway Administration (FHWA), citing Intellichoice's *The Complete Car Cost Guide and Complete Small Truck Guide,* reports figures on the cost of owning and operating automobiles, vans and light trucks. These estimates are based on the annual average costs over five years, assuming 70,000 miles driven, and include depreciation, insurance, financing, fuel cost, maintenance, state fees, and repairs.

The transportation model developed for the H+T Index has been constructed to estimate auto ownership per household, vehicle miles traveled per household, and public transit use, to which cost components are multiplied.

Auto ownership costs, for the purposes of this research, were defined as depreciation, finance charges, insurance, license, registration, and taxes (state fees). These costs were chosen as ownership costs, as they are deemed largely fixed (i.e., less determined by use), and therefore a result of simply owning an automobile.

Auto use costs, for the purposes of this research, were defined as gas, maintenance, and repairs. These costs were chosen as use costs as they are largely variable and determined primarily by the level of use of the automobile.

It should be noted that the study does not include parking costs as part of either auto ownership or use, due to the variation in cost by location and a lack of data that makes accurate classification impossible. For instance, parking in dense urban areas, for both residents and commuters driving in from the suburbs, can cost up to $300 per month. In the case of residents parking, this would be classified as an ownership cost; in the case of commuters parking, it would be classified as a use cost.

Transit costs factor the average cost of transit use per household using a regional average price as derived from the National Transit Database (details follow in Cost Components section).

To develop the model, a non-linear regression analysis was conducted for each of the three dependent variables in which the set of independent variables was tested to determine their significance in describing the variation observed in each dependent variable. A set of formulae was then created equating the appropriate variables.

As an example, a histogram of the block group level autos per household for the District (as derived from the 2000 US Census), with frequency representing the count of block groups, shows the mean value and distribution of the data (fig. 41). This shows that block group average values for autos per household range from approximately 0.1 to 2.3, with a mean value of 0.96 autos per household in DC.

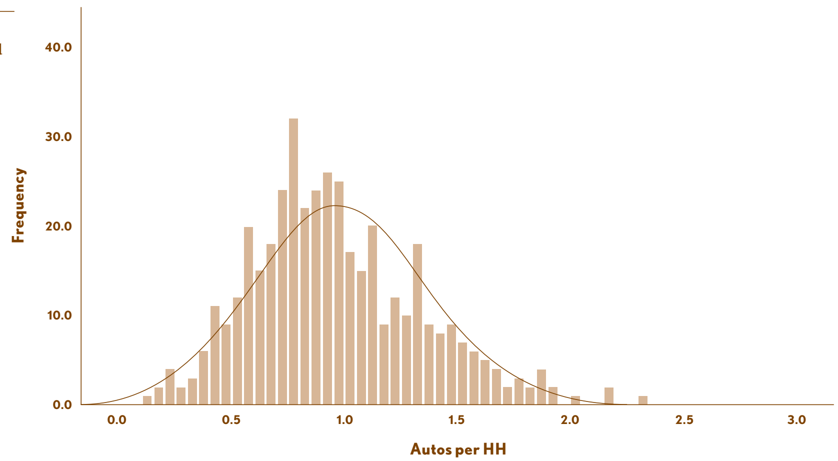


FIGURE 41
Histogram of autos per household by census block group in DC (2000 US census)

Mean = .96114546
Std. Dev. = .378763385
N = 422

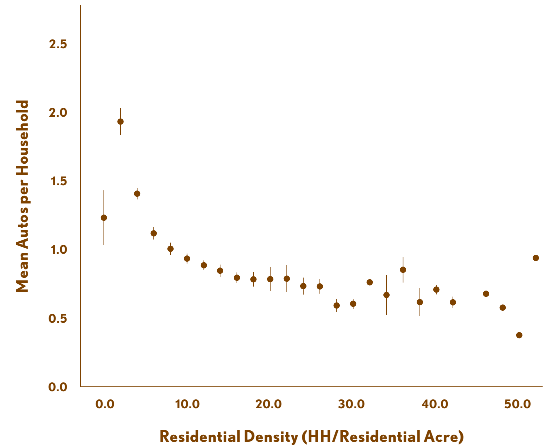


FIGURE 42
Average autos per household plotted relative to residential density

To explain the variation in average autos per household, the correlation of several independent variables were tested. Figure 42 shows the relationship between average autos per household and residential density as an example. A regression was run to fit a curve describing the relationship between the dependent (autos per household) and independent (residential density) variables. In a perfect regression (one in which all variation has been described), the modeled data perfectly replicate the measured data. To assess the goodness of fit, residual values (measured data minus modeled data) were considered. If all of the variation has been described, the plot of residual values versus the independent variable will be flat (fig. 43). An ANOVA (analysis of variance) indicated that an R-squared value of 0.437 was achieved in this example, meaning that 43.7% of the variation observed in auto per household can be described by residential density (table 9).

This example indicated that some variation persisted and that the dependent variable of autos per household was not solely a function of the independent variable of residential density. Therefore, this process was repeated and additional independent variables were tested and incorporated into the fit. The model was expanded until the addition of new independent variables no longer significantly improved the R-squared value.

FIGURE 43
Residual values versus independent residential density variable

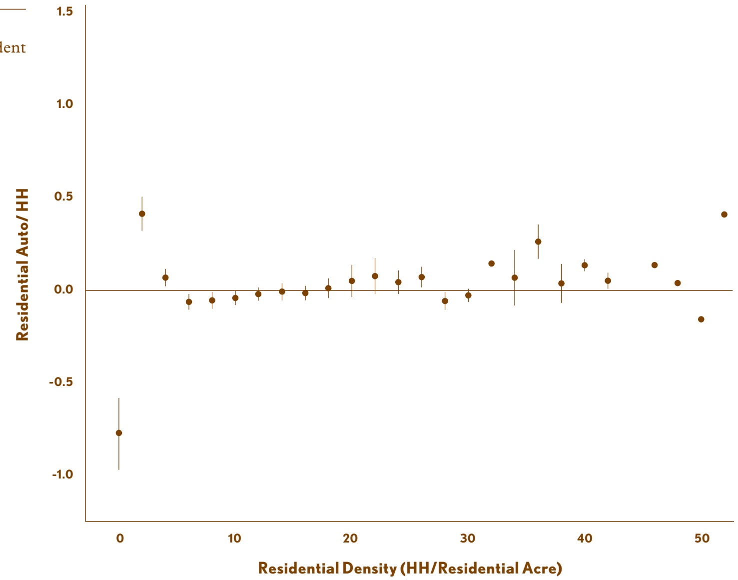


TABLE 9
Analysis of variance between measured and modeled data for autos per household, as fit for residential density

Source	Sum of Squares	df	Mean Squares
Regression	**416.241**	**3**	**138.747**
Residual	**34.000**	**419**	**.081**
Uncorrected Total	**450.241**	**422**	
Corrected Total	**60.397**	**421**	

ANOVA[A]
Dependent Variable: Autos per HH
a. R-squared = 1 - (Residual Sum of Squares) / (Corrected Sum of Squares) = .437

Dependent Variables—Measured Data

AUTOS PER HOUSEHOLD

For the dependent variable of auto ownership, the regression analysis was fit using measured data on auto ownership obtained from the 2000 US Census and the 2006–2008 American Community Survey. As described above, the constant share method was applied to the two datasets to estimate block group level values representing 2006–2008. Aggregate Number of Vehicles Available by Tenure defined the total number of vehicles, and Tenure defined the universe of Occupied Housing Units. Average vehicles per occupied housing unit were calculated.

AUTO USE

Auto use was measured as vehicle miles traveled (VMT) per automobile. In order to determine the amount that households drive their autos, odometer readings were utilized. Data were obtained for one region of the country, the optimum formula was determined using the independent variables in that region, and these formulae were then applied to the study area. Odometer readings for the time period of 2005–2007 were obtained from the Massachusetts Department of Transportation for the entire state at a 250-meter grid cell level. A similar dataset for the greater Chicago area was analyzed at the zip code level and compared with the Massachusetts dataset resulting in similar relationships with the independent variables. Due to the geographic scale of the Massachusetts dataset, the regression analysis was fit using these data.

PUBLIC TRANSIT USE

Because no direct measure of transit use was available at the block group level, a proxy was utilized for the measured data representing the dependent variable of transit use. Again from the 2000 US Census and the 2006–2008 American Community Survey, Means of Transportation to Work was used to calculate a percentage of commuters utilizing public transit.

Independent Variables

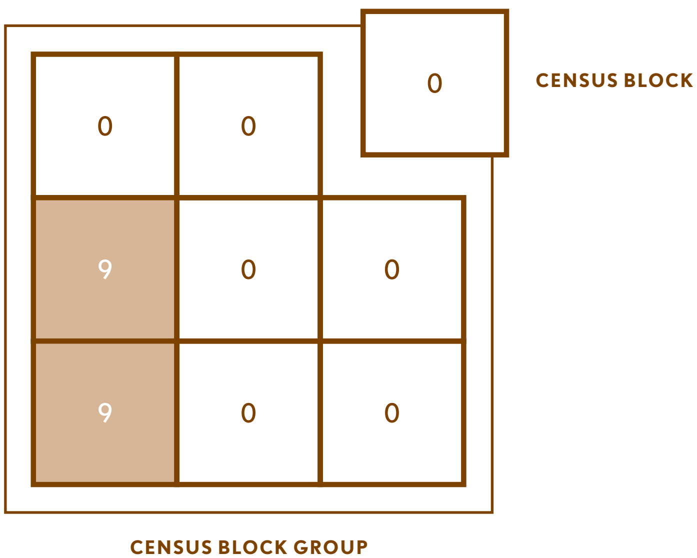
Literature and previous research revealed many potential independent variables significant in explaining the variation observed in auto ownership, auto use, and public transit use. The following variables representing both neighborhood and household characteristics were tested and utilized where appropriate. Independent variables were fit one at a time, starting with the one that appeared to have the strongest correlation with the given dependent variable. After the first independent variable was fit, the remaining independent variables were plotted with the resulting residual values. The independent variable that appeared to have the strongest correlation with the residual values was added second. This process was repeated with all independent variables, and only those that improved the fit were kept in the final fit.

As discussed above, it has been found that the addition of detailed local datasets as independent variables can help improve the fit, and therefore accuracy, of the regression analyses. However, because these data were obtained from various local agencies, geographic coverage of the datasets varied. Therefore, two separate sets of regression analyses needed to be constructed: The General, Full Region model (the General Model) for the full study area,[19] fit utilizing the standard independent variables; and the Refined, Small Region Model (the Refined Model) for a smaller geography,[20] refined through the incorporation of the local datasets. The General Model is used throughout this report, while the Refined Model is only addressed when explicitly discussing the differences between the two models.

FIGURE 44
Calculating gross and residential density at the block group level

GROSS DENSITY
2 UNITS/ACRE

RESIDENTIAL DENSITY
9 UNITS/ACRE



RESIDENTIAL DENSITY

Residential density represents household density of residential areas, in contrast to population density on land area. Our research has shown that by isolating residential land, residential density correlates more strongly with the dependent variables than a gross density measure of households per total land acres. As one method to identify and isolate residential land, total households were obtained at the Census block level. Only blocks that contain at least one household per land acre were deemed residential. To calculate residential density at the block group level, total households and land acres of these selected residential blocks were aggregated to the block group, at which level households were divided by total residential acres (figure 44 illustrates this graphically).

RESIDENTIAL DENSITY WITH LAND USE DATA

Another method of calculating residential density was accomplished through the use of detailed land use data. Land use data, in the most accurate and detailed form available, was collected for all jurisdictions in the Refined Model study area (see table 10). Any land use classification that could contain housing (e.g., mixed use) was identified as residential, and the acreage was aggregated to the block group level. Total households in a block group, divided by this measure of residential acreage, estimated the block group residential density value.

19. The General Model's 23-jurisdiction study area comprises the District of Columbia; Calvert, Charles, Frederick, Montgomery, and Prince George's counties, MD; Arlington, Clarke, Culpeper, Fairfax, Fauquier, King George, Loudoun, Prince William, Spotsylvania, Stafford, and Warren counties, VA; and the cities of Alexandria, Fairfax, Falls Church, Fredericksburg, Manassas, and Manassas Park, VA.

20. The Refined Model's 8-jurisdiction study area comprises the District of Columbia; Montgomery and Prince George's counties, MD; Arlington and Fairfax counties, VA; and the cities of Alexandria, Fairfax, and Falls Church, VA. Jurisdictions were chosen based on the geographic extent of DC's transit network analysis.

TABLE 10
Land use data collected and type

Name	Type	State	Land Use Data
District of Columbia		**DC**	**Tax Record/Parcel and Land Use**
Montgomery	**County**	**MD**	**Land Use**
Prince George's	**County**	**MD**	**Land Use**
Arlington	**County**	**VA**	**Parcel Data and Zoning**
Fairfax	**County**	**VA**	**Land Use**
Alexandria	**City**	**VA**	**Parcel**
Fairfax	**City**	**VA**	**Zoning**
Falls Church	**City**	**VA**	**Land Use**

This method of defining residential acreage, and therefore residential density, was tested only in the Refined Model regression analyses.

GROSS DENSITY

While residential density has been found to correlate more strongly with the dependent variables, gross density (total households divided by total land acres) also correlates and has been found to improve the fit above and beyond residential density alone.

LAND USE DIVERSITY

A significant development in this research was the incorporation of land use data, both in defining residential acres as described above, but also in developing a measure of land use diversity. Other research has shown that the level of land use mix or diversity shows a significant correlation with auto ownership, auto use, and transit use. Increasing land use mix allows residents in neighborhoods to have more transportation choice in how they meet their daily needs.[21] There has been some work to show that having more diverse land use in a neighborhood manifests itself in reduced driving and auto ownership.[22] These assumptions were tested by examining some measures of land use diversity,[23] and by examining which measures best correlated with auto ownership, auto usage, and transit usage. To test this, various measures of land use diversity were constructed and tested.

To construct these measures, general land use types were first identified and consolidated between the various land-use datasets obtained from local agencies (see table 10). Thirteen general land use types were identified, as shown in table 11. These types were defined with the necessity that every land use classification provided in the original datasets must be classified into one of the thirteen types. Each dataset had its own version of unidentified land, which therefore required the creation of four classifications that were not used in the land use

TABLE 11
Land-use categories

	General Land Use Classification	Description
1	**Residential**	Residential land
2	**Commercial**	Commercial land, including mixed use when defined
3	**Industrial**	Industrial land
4	**Institutional**	Institutional land—universities, hospitals, government agencies, etc.
5	**Agriculture**	Agricultural land when defined
6	**Park**	Parks
7	**Water**	Open water
8	**TCU**	Transportation, communication and utilities
9	**Open**	Open land—forests, beaches, other non-park open space
10	**Other**	These three categories were defined by the different data providers; we assume these are undefined, and keep them as separate categories
11	**Unknown**	
12	**NA**	
13	**Acres left over**	Calculated land area in Census block groups that is not defined

21. Evaluating Transportation Land Use Impacts: http://www.vtpi.org/landuse.pdf
22. For some examples see the article "Land Use Impacts on Transport, How Land Use Patterns Affect Travel Behavior" in the TDM Encyclopedia http://www.vtpi.org/tdm/tdm20.htm#_Toc119886791
23. Robert Cervero, et al (2004), *Transit-Oriented Development in the United States: Experience, Challenges, and Prospects*, Transit Cooperative Research Program, Transportation Research Board (http://gulliver.trb.org/publications/tcrp/tcrp_rpt_102.pdf).

diversity measures: other, unknown, NA, and acres left over. Each land-use dataset was modified to fit within this structure.

Utilizing these thirteen land use types, three basic forms of land-use diversity measures were considered: percent residential, Herfindahl-Hirschman indices, and entropy indices.[24] These measures were considered both directly within each block group as well as using a gravity measure to diminish the modifiable areal unit problem (or MAUP).[25] The definition of gravity, for the purposes of this study, is:

$$G \equiv \sum_{i=1}^{n} \frac{p_i}{r_i^2}$$

TABLE 12
Land-use diversity measures

Measure	Elements
Percent Residential	Residential
HH 2	Residential, Non-residential
HH 3	Residential, Employment, Non-residential-employment
HH 4	Residential, Employment, Park, Not-intense
HH 6	Residential, Commercial, Industrial, Institutional park, Not-intense
Entropy 2	Residential, Non-residential
Entropy 3	Residential, Employment, Non-residential-employment
Entropy 4	Residential, Employment, Park, Not-intense
Entropy 6	Residential, Commercial, Industrial, Institutional park, Not-intense

Where G is the gravity measure itself, n is the total number of measurements, P_i is the statistic (e.g., acres of residential land), and r_i is the distance from the given Census block group to the center of the grid cell. For this study we used a grid cell of 250m by 250m and measured the land use within each cell.

The measures shown in table 12 were calculated and tested, both as raw number values within the block groups, as well as by using a gravity measure as stated above. The definitions of the land use classifications as they pertain to Levels 2, 3, 4 and 6 of both the Herfindahl-Hirschman indices and the entropy indices are defined in table 13. As with the overall regression methods, the measures that correlated best and provided the greatest marginal improvement to the overall fits were included.

These methods of defining land use diversity were tested only in the Refined Model regression analyses.

AVERAGE BLOCK SIZE

The average block size in an area was used to represent street connectivity and pedestrian friendliness, which influences travel mode and distance traveled. Greater connectivity, from more streets and intersections, creates smaller blocks, and tends to lead to more frequent walking and biking trips, as well as shorter average trips. Census TIGER/Line files were utilized to calculate average block size (in acres) as the total block group area divided by the number of Census blocks within the block group. This measure is similar to intersection density, another commonly used indicator of walkability.

TRANSIT CONNECTIVITY INDEX

The significance of transit service levels were measured through the use of the Transit Connectivity Index (TCI), an index developed by CNT. The availability of local datasets is critical for this transit measure. In previous iterations of the transportation model, data have not been available to incorporate all regional bus routes and the frequency of service in the DC area. These data were obtained for

24. Yan Song and Daniel A. Rodriguez, "The Measurement of the Level of Mixed Land Use: A Synthetic Approach." From: http://planningandactivity.unc.edu/RP3.htm
25. Ibid.

TABLE 13
Definition of land-use grouping

General Land Use Classification	Level 2	Level 3	Level 4	Level 6
1 **Residential**	Residential	Residential	Residential	Residential
2 **Commercial**	Non-Residential	Employment	Employment	Commercial
3 **Industrial**				Industrial
4 **Institutional**				Institutional
5 **Agriculture**		Non-Residential-Employment	Not-Intense	Not-Intense
6 **Park**			Park	Park
7 **Water**			Not-Intense	Not-Intense
8 **TCU**				
9 **Open**				
10 **Other**				
11 **Unknown**				
12 **NA**				
13 **Acres left over**				

use in this study. In the TCI, transit service levels were calculated as the number of bus routes and train stations within walking distance (¼ mile and ½ mile, respectively) for households in a given block group scaled by the frequency of service. The index value therefore represents the average rides per week available to households in a given block group.

DC OP'S TRANSIT NETWORK ANALYSIS

Another measure by which to evaluate transit accessibility was provided and modeled by the DC Office of Planning (OP). A transit network analysis model was developed to model the distance that can be traveled in 30 minutes through walking and transit. Using this model in conjunction with the land use classifications (see table 11), OP estimated the total acreage of each land use type accessible by transit and walking from the center of each block group in the study area.

These modeled results were utilized to create two distinct measures of accessibility: the total acreage of each land use type as well as the sum of all types accessible; and, of the total acreage accessible, the fraction of each land use type. Again, as with the land use diversity measures, the transit network analysis measures that correlated best and provided the greatest marginal improvement to the overall fits were included.

These methods of measuring transit access, as provided by the DC Office of Planning, were only tested and incorporated in the Refined Model regression analyses.

EMPLOYMENT ACCESS

Proximity to regional employment was determined using a gravity model, which considered both the quantity of and distance to all such destinations, relative to any given block group. Using an inverse-square law, an employment index was calculated by summing the total number of jobs divided by the square of the distance to those jobs. This quantity allowed examination of both the existence of jobs and the accessibility of these jobs for a given census block group. Because a gravity model enables consideration of jobs both directly and not directly in a given block group, the employment access index gave a better measure of job opportunity, and thus a better understanding of job access than a simple employment density measure.

To calculate the employment access index, data pertaining to the locations of all jobs in a region were obtained from the 2000 Census Transportation Planning Products (CTPP). The index was calculated as:

$$E \equiv \sum_{i=1}^{n} \frac{p_i}{r_i^2}$$

Where E is the employment access for a given Census block group, n is the total number of census tracts in the region, P_i is the number of jobs in the ith Census tract, and r_i is the distance (in miles) from the center of the given census block group to the center of the ith Census tract.

AVERAGE JOURNEY TO WORK TIME

Average journey to work time was calculated using the Census Bureau series Aggregate Travel Time to Work (in minutes) by Travel Time to Work by Means of Transportation to Work, and Means of Transportation to Work, to define the universe of Workers 16 Years and Over Who Did Not Work at Home, again from the 2000 US Census and the 2006–2008 ACS. Average journey to work time was calculated at the block group level in minutes.

MEDIAN HOUSEHOLD INCOME

Median household income was obtained from the 2000 US Census and the 2006–2008 ACS.

AVERAGE HOUSEHOLD SIZE

Average household size was obtained from the 2000 US Census and the 2006–2008 ACS. Total Population in Occupied Housing Units by Tenure was utilized in conjunction with Tenure, which was used to define the universe of occupied housing units.

AVERAGE COMMUTERS PER HOUSEHOLD

Average commuters per household was calculated using the figures for Total Workers 16 Years and Over Who Do Not Work at Home from Means of Transportation to Work, and Tenure to define occupied housing units. Because Means of Transportation to Work includes workers not living in occupied housing units (i.e., those living in group quarters), the ratio of Total Population in Occupied Housing Units to Total Population was used to scale the count of commuters to better represent those living in households. Again, all data were obtained from the 2000 US Census and the 2006–2008 ACS.

CONTROLLING FOR HOUSEHOLD VARIATION

Because the model was constructed to estimate the three dependent variables (auto ownership, auto use, and transit use) as functions of independent variables, any set of independent variables can be altered to see how the outputs are affected. As a way to focus on the built environment, the independent household variables (income, household size, and commuters per household) were set at fixed values. This controlled for any variation in the dependent variables that was a function of household characteristics, leaving the remaining variation a sole function of the built environment. In other words, by establishing and running the model for a "typical household," any variation observed in transportation costs is due to place and location, not household characteristics.

To define the values on which these three parameters were fixed (household income, household size, and commuters per household), block group level values were averaged for the full region study area ($87,623, 2.65, and 1.37 respectively). Therefore, for the purposes of this study, the reported "AMI" represents the regional average of block group level household median income values.

Cost Components

As discussed above, the predicted results from each model were multiplied by the appropriate price for each unit—autos, miles, and transit trips—to obtain the cost of that aspect of transportation. This is summarized as follows:

Household T Costs =
$$[C_{AO} {*} F_{AO}(X)] + [C_{AU} {*} F_{AU}(X)] + [C_{TU} {*} F_{TU}(X)]$$

Where $C \equiv$ cost factor (e.g., dollars per mile) and $F \equiv$ function of the independent variables, X.

AUTO OWNERSHIP COSTS

Year	Ownership Costs
2006	**$5,569**
2007	**$5,648**
2008	**$5,576**
Average	**$5,598**

TABLE 14
AAA *Your Driving Costs*: average annual ownership costs

AUTO USE COSTS

TABLE 15
AAA *Your Driving Costs*: average annual operating costs (minus gasoline costs) in cents per mile

Year	Maintenance	Tires	Total
2006	**4.9¢**	**0.7¢**	**5.6¢**
2007	**4.9¢**	**0.7¢**	**5.6¢**
2008	**4.57¢**	**0.72¢**	**5.29¢**
Average			**5.50¢**

TABLE 16
EIA: Central Atlantic (PADD 1B) regular all formulations retail gasoline prices (MG_RT_1B)

Year	Gasoline Cost per Gallon
2006	**261.8¢**
2007	**279.0¢**
2008	**327.1¢**
Average	**289.3¢**
Assumed Fuel Efficiency 20.3 mpg	**14.25¢ per mile**
Total 2006–08 Average Operating Costs	**19.75¢ per mile**

TRANSIT USE COSTS

To identify transit use costs, the National Transit Database (NTD) was used to identify the total farebox revenue from transit agencies. The total revenue for all agencies serving the DC region was aggregated to the urbanized area, as that is the geography that the NTD uses to report its data. The urbanized area was brought into GIS and the data were proportionally summed to the study area included in this analysis. The proportion of the total transit commuters in the urbanized area was used to estimate the total transit revenue within the urbanized area. Once that amount was assigned to the urbanized area, the total revenue was divided by the total transit commuters to come up with an average fare per transit commuter. Thus, the total expenditure for transit for all the households in the urbanized area is equal to the farebox revenue for all of the transit agencies that serve the region.

For more information, contact **CNT** 773 278 4800 info@cnt.org