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Neighborhood services, trip purpose, and tour-based travel

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Abstract. Communities are increasingly looking to land use planning strategies to reduce drive-alone travel. Many planning efforts aim to develop neighborhoods with higher levels of accessibility that will allow residents to shop closer to home and drive fewer miles. To better understand how accessible land use patterns relate to household travel behavior, this paper is divided into three sections. The first section describes the typical range of services available in areas with high neighborhood accessibility. It explains how trip-based travel analysis is limited because it does not consider the linked (chained) nature of most travel. The second section describes a framework that provides a more behavioral understanding of household travel. This framework highlights travel tours, the sequence of trips that begin and end at home, as the basic unit of analysis. The paper offers a typology of travel tours to account for different travel purposes; by doing so, this typology helps understand tours relative to the range of services typically offered in accessible neighborhoods. The final section empirically analyzes relationships between tour type and neighborhood access using detailed travel data from the Central Puget Sound region (Seattle, Washington). Households living in areas with higher levels of neighborhood access are found to complete more tours and make fewer stops per tour. They make more simple tours (out and back) for work and maintenance (personal, appointment, and shopping) trip purposes but there is no difference in the frequency of other types of tours. While they travel shorter distances for maintenance-type errands, a large portion of their maintenance travel is still pursued outside the neighborhood. These findings suggest that while higher levels of neighborhood access influences travel tours, it does not spur households to complete the bulk of their errands close to home.

Abbreviations: NA – neighborhood accessibility

The idea of using land use patterns to influence travel is popular in planning circles these days. Low density development, single-use zoning, and cul-de-sacs are the target of attacks against sprawl and auto-dependant travel. State, regional, and local governments are responding with planning proposals to reduce the amount of drive-alone travel by coordinating land use with transportation planning. These plans urge compact development, land use mix, plus urban design improvements (e.g., sidewalks, street crossings, smaller blocks).

Such development types have been labeled new urbanist, neotraditional development, transit-oriented development, traditional neighborhood design or pedestrian pockets. From a transportation perspective, each aims to provide increased levels of neighborhood access (hereafter NA) that allow residents to shop closer to home and drive fewer miles.[1] But how do increased levels of neighborhood accessibility relate to the manner in which individuals complete daily errands? What is the potential of NA to reduce vehicle miles of travel?

Consider the following two scenarios. Both Judy and Johnny live in a highly accessible neighborhoods. Judy completes several errands (e.g., groceries, appointments) during her drive home from work, each of which are close to her workplace location. Despite living close to basic services, her preferences trigger her choice to shop outside of her neighborhood. Or consider Johnny who drives once a week from home to the dry cleaner. His decision to drive is not because a car is required for this trip to the dry cleaner; rather, it is because the dry cleaner trip is done on the way to the weekly trip to the grocer – a trip requiring a car in the first place. In each case the individual's high NA plays a small, if not insignificant, role in driving less. This is because the *sequence* and *combination* of trips – not the individual trips themselves – are important considerations influencing travel decisions.

To further our understanding of these phenomena, the objective of this research is to focus on the following relationships: (1) between NA and trip purpose, and (2) between NA and the manner in which such trips are combined (i.e., travel tours). The paper is divided into three parts. The first section describes the typical range of services offered in areas with high NA. It explains the shortcomings of typical travel analysis and how trip-based approaches are limited in their understanding of household behavior. The second section offers a framework to provide a more behavioral description of household travel. The framework highlights travel tours – the sequence of trips that begin and end at home and offers a typology of travel tours that considers different travel purposes. This typology advances our understanding of daily tours relative to the range of services typically offered in more accessible neighborhoods. The final section empirically analyzes relationships between tour type and NA using detailed travel data from the Central Puget Sound (Seattle, Washington).

Crudely simplified, the findings suggest that households with higher levels of NA leave home more often and make fewer stops when they do leave home. They make more simple tours (out and back) for work and maintenance (personal, appointment, and shopping) trip purposes but there remains no difference in the frequency of other types of tours. While households with higher NA travel shorter distances for maintenance-type errands, a large portion of their maintenance travel is still outside the neighborhood. In fact, households with high NA complete a mere 20 percent of their simple maintenance tours within 3.2 km (2.0 mi) of their home. Thus, the often touted VMT savings of living close to services appears to be negligible.

Part I. Accessible neighborhoods and travel purpose

The analysis begins by describing the basic purposes for which households travel. To the extent that travel is a derived demand (i.e., individuals do things in different places – work, recreation, shopping, health services), it is important to understand such activities. The success of NA to influence travel behavior depends in large part on the opportunities that are provided for. It is axiomatic, yet worth repeating, that the variety, location, and type of destinations is critical.

Crane (1996) discusses in detail trip demand models that can be specified by urban design feature and trip purpose. The reader is urged to consult his application of price and cost concepts to issues of trip generation and accessibility. The discussion provides important, yet often overlooked, assumptions related to urban form and travel. He does not, however, speak to the different purposes of travel that may most likely be influenced by NA.

To date, this discussion is best addressed by Handy (1992), who describes how higher levels of NA are hypothesized to influence non-work travel. The ubiquitous transportation network in most US metropolitan areas relaxes the assumption that households choose residential locations close to their employment location. But while the once prominent role of the work commute is rapidly diminishing, commute patterns are still relatively fIXed. They tend to be constrained by larger forces such as time of day and route.

This suggests that non-commute travel (i.e., non-work) is more flexible and potentially more likely influenced by levels of NA. Subsequently, the simply disguised distinction between work and non-work travel is one commonly considered in literature (Ewing et al. 1994; Ewing 1995; Kockelman 1996; Cervero & Kockelman 1997; Boarnet & Sarmiento 1998; Crane & Crepeau 1998; Boarnet & Greenwald 2000). This literature, while extensive, remains mixed in its conclusions. On one hand, the reader is referred to a recent review by Ewing and Cervero (2001) describing significant elasticities of travel demand with respect to variables measuring the built environment. On the other hand, a review by Crane (2000) argues that our current understanding of this complex group of relationships remains tentative; he therefore concludes that "not much can be said to policy makers as to whether the use of urban design and land use planning can help reduce traffic."

Past analysis is confounded by the fact that a simple *work/non-work* classification does not do justice to understanding how travel behavior is influenced by urban form. First, suggesting that non-work travel is more

Table 1. Different examples of accessible neighborhoods.

Source	Classification	Typical mix of uses
TODs (Calthorpe 1993)	Urban TOD	High commercial intensities, job clusters, and moderate to high residential densities (5–15% public, 30–70% core/employments, 20–60% housing)
	Neighborhood TOD	Moderate density residential, service, retail, entertainment, civic and recreational uses (10–15% public, 10–40% core/employment, 50–80% housing)
Seattle (City of Seattle 1996)	HUB Urban Village	• A mix of densities, and non-residential activities that support residential use • At least one-third of the land area zoned to accommodate employment activity and/or mixed-use • A broad range of commercial and retail support services to serve a local, citywide or regional market
	Residential Urban Village	• Residential use (8–15 units/gross acre) is emphasized, a mix of other compatible activities, especially those that support residential uses • Employment activity is appropriate to the extent that it does not conflict with the overall residential function and character of the village
	Neighborhood Anchor	• 2–3 linear blocks zoned for commercial activity and provide services to areas that generally range in size from 5 to 20 acres; serves as a node of mixed residential and commercial activity
Portland (Tri-Met 1993)	Mixed Use Centers	Class A office, ground floor retail, high density housing
	Urban Neighborhoods	High density housing, retail, small-scale office
	Urban Corridors	High density housing, retail, small-scale office
	Suburban Neighborhoods	Moderate density housing, local retail
	Suburban Employment Centers	Campus employment, light industrial, institutional

influenced by levels of NA oversimplifies the range of services often included in such neighborhoods. Second, analysis that separates work trips from non-work trips is unable to account for travel that links multiple purposes. Each is addressed in more detail below.

A popular account describing the concept of transit oriented development (TOD), a close cousin to high NA, calls for Urban TODs and Neighborhood TODs (Calthorpe 1993). The range of uses for Urban and Neighborhood TODs, together with closely aligned styles of development, are described in Table 1. At a minimum, all TODs have residential densities between 12–25 dwelling units per acre supplemented by a core area of convenience retail and local-serving offices. Types of commercial centers include:

- convenience shopping (930 to 2,325 m^2/10,000 to 25,000 ft^2);
- neighborhood centers with a supermarket, drugstore, and supporting uses (7,440 to 13,020 m^2/80,000 to 140,000 ft^2);
- specialty retail centers (5,580 to 11,160 m^2/60,000 to 120,000 ft^2); and
- community centers with convenience shopping and department stores (11,160 m^2/120,000 ft^2 or greater) (Calthorpe 1993).

Design guidelines mirroring this type of development are applied in planning initiatives nationwide. For example, Seattle's comprehensive plan prescribes HUB Urban Villages, Residential Urban Villages, and Neighborhood Anchors, all with varying intensities and uses. Portland Metro calls for five different classifications of pedestrian districts. Table 1 provides general guidelines for the types of activities.

But how do the ranges of activities in accessible neighborhoods compare with the types of activities for which households travel? As a starting point, Table 2 comments on the likelihood eight different purposes of travel would be available in areas with high NA. The right column of Table 2 describes how travel for five purposes (appointments, personal, college, school, and shopping) would likely be available in areas with high NA; in contrast, trip purposes related to work, free-time, or visiting do not appear to have similar drawing power.

Part II. Introducing tour-based analysis

Analysis that separates different types of trips, however, suffers from two related problems: (1) it considers each type of trip in an isolated manner, and (2) it does not allow a means to account for travel combining multiple purposes. Examining individual trips instead of the larger pattern of linked trips fails to work with the basic forces that generate and influence travel. Knowing the extent to which NA can moderate travel, however, requires us

Table 2. Travel purpose and the author's assessment of the likelihood that purpose will be available in areas with high neighborhood accessibility (NA).

Purpose of travel	Comment on the likelihood travel type is contained within an area considered to have high neighborhood access
Work	When considering residential areas based on NA, major employment opportunities are not likely. Even a careful read of many designs for new-urbanist villages reveals that employment is not a major feature of such designs. Furthermore, when employment opportunities would be available within the neighborhood, there is seldom a satisfactory match between the residents' skills or preferences and the jobs offered.
Personal (getting a service done or completing a transaction, e.g. banking, gas station, dry cleaning)	Advocates of NA would contend that most of these activities, if not all, would be available within the neighborhood domain.
Free-time (non-task oriented activities, e.g., entertainment, dining, theater, sports, church clubs, library, exercise)	The relatively wide range of activities available in this category makes it difficult to posit which ones are likely to be within a community with high NA, though most would certainly be available.
Shopping (travel to buy concrete things) However, shopping services (as suggested by Handy (1992)) can be divided into the following 3 categories:	***Convenience*** shopping (e.g., bread, milk) is the activity most heralded by NA designs; every neighborhood based on principles of NA is urged to have a corner store. ***Comparison*** goods shopping (e.g., furniture, appliance, clothing) which is increasingly being satisfied by "big-box" and "super-stores" who tend to locate on large tracts of land with ample parking. Such locations are typically the antithesis of areas with high NA. ***Specialty*** goods shopping (e.g., niche markets, boutiques) typically involve shopping which customers will put forth special effort to visit. Their size and nature meshes well with NA designs.
Appointment (activities to be done at a particular time, e.g. doctor's appointment, meeting)	One would expect a residential neighborhood to have standard appointment services (e.g., dentists, general physician) but not necessarily more specialized services.
Visiting	One would expect a close locale of people in highly accessible neighborhoods. However, personal, cultural, and socio-demographic preferences do not ensure they will be nearby.
School	Schools are strongly urged, especially elementary schools. With each advance in education level, however, the likelihood of being within a residential neighborhood decreases rapidly.
College	Where colleges and universities are present in neighborhoods, they are most likely an intricate part of the community.

to understand such phenomena. Many planners and decision makers assume residents will shop and travel local to their neighborhood once basic services become available. Such assertions fail to account for the fact that residents link trips with forays outside the neighborhood, thereby marginalizing the effect that NA may have on reduced auto use.

Two decades of research suggest strategies to circumvent what has been referred to as the isolated trip approach (Damm 1982). A technique for taming the complexity of travel involves organizing travel into multi-stop trips commonly known as tours or trip chains. Tours recognize that travel is a function of many factors including types of destinations, previous destinations, subsequent destinations, travel mode, and individual characteristics. They provide an intuitive way to grasp the interrelated decision process of linked trips. Considering tours across a day, sequence of days, or even a week provides a means to more robustly track the schedule and travel of individuals.

Approaches to operationalizing tours

While the idea of multi-stop journeys is straightforward, the concept is more difficult to operationalize. This section discusses factors that influence the nature of tours, a task that has been partially completed in the literature reviewed thus far (see Thill & Thomas 1987). Tours represent a cornerstone of current activity-based transportation modeling efforts (e.g., TRANSIMS) currently underway (Kitamura 1988; Ben-Akiva & Bowman 1998; Bowman et al. 1998; Bhat et al. 1999; Misra & Bhat 2000; Jonnalagadda et al. 2001).

While measured in variety of contexts, the literature most often defines a tour in terms of the home-to-home loop and then analyzes it by looking at the number of trips (i.e., stops). Simple tours contain two trips (e.g., home to work and then work to home); complex tours contain more than two trips. Adler and Ben-Akiva (1979) develop a theoretical model that explicitly accounts for the trade-offs involved in the choice of multiple-stop chains. Using a cross between qualitative and quantitative research Clark et al. (1981) draw correlations between trip chain complexity, household characteristics, and life-cycle. Recker et al.'s (1985) analysis shows that the likelihood of chaining trips is positively associated with the number of trips taken and negatively related to activity duration, employment status, and age. Williams (1988) considers household activity, trip frequency, and travel time in concert with accessibility indices to show that residents in less accessible areas have higher likelihood to form trip chains and have higher trip frequencies. Strathman et al. (1994) analyze trip chaining differences among household types by developing models to estimate the propensity to link non-work trips to the work commute and to estimate non-work travel by three chain types: work commutes, multi-stop non-work journeys, and unlinked trips. More recently, Wallace et al. (2000) estimate a model to predict the number of trips in a chain based on characteristics of the household, the traveler, trip type, and the origin location.

Analyzing the nature and frequency of simple versus complex tours, however, only considers one dimension of the tour: number of stops. It does not do justice to how a separate dimension of travel – purpose. Travel purpose is important to consider because land use initiatives based on NA potentially capture different types of travel

Accounting for multi-purpose tours

Using tours as a unit of analysis prompts an important challenge: how to assign a single purpose to what is often a multi-trip/multi-purpose tour? To better capture how different purposes of travel – a nominal variable – interact with trips, classification emerges as a preferred strategy. Though the lowest form of measurement, classification allows many variables to be considered simultaneously (e.g., the purpose and/or number of trips on a tour). Only a handful or so studies present different ways to analyze travel behavior using tours (or chains) that specify different purposes of travel.

Table 3 presents categories of travel used in prior classification schemes. Pas (1982) developed a similarity index of travel activity to identify single types of travel for a person over a day. Homogeneous types of travel were grouped together by a twelve cluster analysis and a five cluster application. A report from Bradley Research et al. (1998) used similar groups of activities, but allowed greater flexibility in how tours were coded. Golob (1986) developed an elaborate typology of tour-types analyzing the transitions between activities. Southworth (1985) used yet a different scheme in efforts to demonstrate a trip chaining simulation model. Ewing (1993) and Hanson (1980) used any work-related trip to binomially code tours as work/non-work. McCormack coded tours by the origin-destination pair as defined by 90 minute cutoff. Similar efforts at classifying travel activity have been used by Recker and McNally (1985), Kansky (1967) and Oppenheim (1975).

Common themes emerge from these eight tour classification schemes. First, the sequence of consecutive trips that begin and end at home is the predominant way to classify a tour. Second, four of the studies use a binary system – work versus non-work – to differentiate between travel purpose within a tour. Other studies specify more detailed non-work trip purposes; Pas and Bradley et al. categorize three types of activities whereas Golob uses six. All of the studies provide a separate category for simple tours, yet they all differ in terms of the combinations and permutations for more complex tours.

A given classification scheme needs to consider the purpose of the study

Table 3. Different strategies for classifying tours.

Golob – 1986
H-W-H
H-W-W-H
H-W-S-H
H-W-other than W/S-H
H-School-H
H-School-X-H
H-P-H
H-SP-H
H-P/SP-other than D/S-H
H-P/SP-S-H
H-P/SP-D-H
H-S-H
H-S-S-H
H-S-D-H
H-D-H
H-D-D-H
H-D-S-H
H-other-H
H-other-other-H
Anything else

Pas – 1982
H-W-H
H-M-H
H-D-H
H-W-X-[X]-H
H-X-…-X-H

Bradley et al. – 1998
H-W-H
H-M-H
H-D-H
H-[X]-W-[X]-H
H-[NW]-M-[NW]-H
H-D-…-D-H

McCormack – 1997
H-W
H-H
H-NW
W-H
W-W
W-NW
NW-W
NW-H
NW-NW

Southworth – 1985
H-X-H
H-X-…-X-H, where X is same purpose
H-X-…-X-H, where X is any purpose
H-[X]-W-X-H
W-X-W

Strathman and Dueker – 1995
H-W-[W]-H
H-NW-[NW/W]-W-H
H-W-[NW/W]-NW-H
H-NW-[NW/W]-W-[NW/W]-NW-H
H-W-[NW/W]-NW-[NW/W]-W-H
H-NW-H
H-NW-[-NW-]-H

Hanson – 1980, Ewing – 1994
H-[X]-W-[X]-H
H-[NW]-NW-[NW]-H

Abbreviations:

H = home	M = maintenance	W = work	SR = social/recreation
D = discretionary	S = shop	NW = nonwork	SP = serve passenger
P = personal	X = any purpose destination		

or application. A detailed coding scheme (e.g., Golob) is advantageous because it more precisely tracks the sequence of detailed travel purposes. While even twenty classifications does not capture all trip-purpose combinations, the permutations of matching merely eight trip purposes with number of trips produces an overly complex bookkeeping matter. On the other hand, simple coding schemes (e.g., Ewing or Hanson) are limited because they do not differentiate between non-work activities – activities that may have very different travel characteristics. To be useful and practical, a taxonomy has to be simple and clear; yet travel is so complex that any classification scheme is admittedly limited in the incremental advancement it provides.

Reichman (1976) first explained that while travel patterns may vary between households, it is still possible to define three major classes of travel-related activities. These three classes represent:

- *subsistence* activities, to which members of the households supply their work and business services; travel associated with this activity is most commonly commuting;
- *maintenance* activities, consisting of the purchase and consumption of convenience goods or personal services needed by the individual or household; and
- *leisure or discretionary* activities, comprising multiple voluntary activities performed on free time, not allocated to work or maintenance activities.

This typology of activities was employed by Pas (1982, 1984) to classify daily travel activity behavior. It has also been used more recently for daily activity modeling (Gould & Golob 1997; Ma & Goulias 1997; Bradley Research et al. 1998). Using this classification scheme, activities for work, school or college trips are considered subsistence (or work). Maintenance activities include personal, appointment, and shopping. Discretionary activities would be visiting and free-time. Aggregating the trip types in such manner provides a means to code and analyze combinations of tours in a way that is more parsimonious than using eight activity types but more detailed than the simple work/non-work dichotomy. Most importantly, separating out maintenance travel allows us to better group and isolate trips more likely to be found in areas with high NA (according to Table 2).

Part III. Relationships between neighborhood accessibility and tour type

Travel and urban form data

The final part of the paper empirically examines relationships between travel tours and neighborhood access using data from the Puget Sound Transportation Panel (PSTP). The PSTP is the first and only general-purpose travel panel survey in the United States (Murakami & Ulberg 1997). It has been conducted annually since 1990 by the Puget Sound Regional Council to track socio-demographic and travel behavior data for the same 1,700 households from King, Snohomish, Pierce, and Kitsap Counties. The household is the unit of analysis for the panel data but travel behavior is recorded using a two-day trip diary completed by each household panel member at least 15 years of age. As recorded in the diary, data for each trip contains the purpose, mode, duration, and distance.

The PSTP includes the composition of the household, socio-demographic/economic characteristics, and the latitude and longitude of both their residential and workplace location. A household's urban form for both their workplace and residential site is measured because both are theorized to influence travel. This research measures urban form around the work and home location at two different scales: (a) the immediate locale – the character of a particular neighborhood, and (b) the position of the neighborhood in the larger region (Handy 1993). The different scales are important to consider because it is theorized that each influences residential location decisions and the nature of household travel. Understanding the partial effect of each is important because issues of NA are more central to neighborhood-scale land use policy debates and new-urbanist initiatives. This analysis therefore focuses on the former (NA) while attempting to control for the role of the later (regional accessibility).

The strategy for measuring the accessibility of a neighborhood within the larger region is computed using a standard gravity model. This approach is consistent with the aims of deriving a measure of activity concentrations that have drawing power from various centers of the Puget Sound region. Opportunities are measured using total retail employment. Of the many ways to account for travel impedance, the most common approach employed specifies an exponential function, $f(\text{impedance}) = \exp_{ij}^{-\beta t}$. The result is a measure of regional accessibility that is similar to that specified by Shen (2000) and Handy (1993) and is specific for each TAZ as follows:

$$regional\_access_i = \sum_j \left[\frac{retail\_employment}{\exp(time_{ij} \times \beta)} \right]$$

where, $time_{ij}$ is the off-peak (free-flow) zone-to-zone travel times by automobile taken from the regional transportation model), and β is an empirically determined parameter (0.2) that best explains variations in distance for all trips.

A combination of three variables – density, land use mix, and street patterns – are used to measure levels of NA. Each variable is measured using units of analysis consisting of 150 meter grid cells; the attributes of each grid cell are not determined by the attributes of that cell alone, but rather influenced by adjoining cells. The values for each grid cell are therefore averaged over a walking distance of one-quarter mile. The reader is referred to documentation elsewhere (Krizek 2003) describing the substantive significance of these variables, their relation to land use-transportation planning initiatives, and a validation exercise for the NA measure. A brief summary is provided below.

Density measures housing units per square mile at the individual block level according using 1990 US Census data. Land use mix is captured by examining retail activity in each grid cell from 1999 data. For every business in the study area, detailed employment data provides: (1) the two digit Standard Industrial Classification Code assigned to the business, (2) the number of employees, and (3) the latitude and longitude coordinates. Rather than use employment for all sectors, only those business types considered to be representative of high NA are included. These business types include food stores, eating and drinking establishments, miscellaneous retail and general merchandise.[2] To account for differences in drawing power of larger establishments, the number of employees per grid cell is tallied (rather than number of businesses). Finally, the grain of the street pattern is used to proxy for the "traditionalness" of the neighborhood and other urban design amenities. Street pattern is operationalized from 1997 US Census Tiger files by calculating the average block area per grid cell. Neighborhoods with higher intersection density – or lower average block area – more closely resemble the street patterns heralded by land use-transportation planners. A single measure of NA is arrived at by combining the three measures into factor scores using principal component factor analysis.

How can the reader be assured that the NA index provides a measure of urban form that captures the phenomenon of interest? As a means to validate the NA index, a panel[3] was asked to assess a sample of 70 neighborhoods throughout the Central Puget Sound according to their degree of NA. They rated each location on a scale of one to six, based on: (a) detailed aerial photographs depicting a quarter-mile radius around an *x-y* coordinate, and (b) anecdotal evidence of the particular neighborhood. The panel was asked to rate each location using more qualitative and experiential information that allowed them to place the neighborhood in a broader context and discuss important characteristics.

An ordinary least squares regression model was estimated using the subjectively assigned NA scores as a dependent variable and the three previously described urban form measures – density, block size, land use mix – as independent variables. The model revealed that each of the three variables were statistically significant with an R-squared value of 0.73, indicating that 73 percent of the variation of the subjectively assigned NA scores assessed by the panel can be explained by these three variables.[4] Similarly, a simple correlation between the NA index and the subjectively assigned NA score revealed a correlation coefficient (r^2) of 0.86 ($p < 0.000$), suggesting the two measures are similar.

Methods of analysis and results

The final part of this paper turns to empirically analyzing the influence NA has on travel behavior. The first look at the data tallies each trip by purpose (Table 4). Because of the interest in the number of destinations to which residents travel, only trips away from home (not those returning to the residence) are counted. Over 33 percent of the trips away from home are for work. This leaves over two-thirds of the trips devoted to non-work activities. The tabulations further divide the trips according to the descriptions in Table 3: trips more likely to be contained in high NA neighborhoods and those less likely. The former tabulation (46.4 percent of all trips) leads many to assert that areas with higher NA could reduce travel. But again, this tells an incomplete story because of the linked nature of many of these trips.

This research therefore classifies the individual trip data into 10,569 tours, where each tour is classified into to one of nine different types according to Table 5. These nine tour types were derived to account for combinations of both: (a) simple and complex tours, and (b) subsistence, maintenance, and discretionary purposes within each tour. Knowing how households combine different purposes – particularly maintenance trips with other types of trips – helps better understand tours, the purposes they contain, and the relation to NA.

To clearly articulate the expected relationships between travel tours and NA, this paper offers three related hypotheses. These hypotheses are tested using

Table 4. Individual trips by purpose.

Trip type	# of trips	% of trips
Shopping	3,210	14.4
Appointment	1,145	5.1
Personal	5,681	25.4
College	325	1.5
Subtotal	10,361	46.4
Free-time	3,306	14.8
Visiting	861	3.9
Work	7,439	33.3
School	371	1.7
Subtotal	11,977	53.7

n = 1,811 households.

Table 5. Tour classification scheme and descriptive statistics for PSTP data.

Type #	Tour type	Coding	% of tours	Mean distance . . . in km (mi)
1	Simple work	H-W-H	23.9	35.6 (22.2)
2	Simple maintenance	H-M-H	20.4	18.1 (11.2)
3	Simple discretionary	H-D-H	12.2	23.9 (14.9)
4	Complex work only	H-W-W-…-H	6.0	63.9 (39.7)
5	Complex maintenance only or Complex discretionary only	H-M-M-…-H H-D-D-…-H	9.9	32.5 (20.2)
6	Complex work + maintenance only	H-W-M-…-H*	1.5	54.0 (33.6)
7	Complex work + discretionary only	H-W-D-…-H*	12.8	53.6 (33.3)
8	Complex maintenance + discretionary only	H-M-D-…-H*	4.2	53.0 (33.0)
9	Complex work + maintenance + discretionary	H-W-M-D-H*	9.1	50.3 (31.2)
			Mean distance = 36.6 (22.8)	

* Tripmaking could take place in any order, n = 1,811 households.

a series of regression models for a sample of 1,811 households (the 1997 wave of the PSTP).[5] Regression models are used to predict the dependent (outcome) variable, which differs in each model representing different tour characteristics. To ensure consistency between each of the models, outcome variables are estimated as a function of the same set of independent variables. The regression models generated are of the sort:

$$T_{characteristic} = f(HC, CD, WA, RA)$$

where:

T = household tour characteristic (number of tours by type, tour complexity, tour distance);

HC = a vector of household characteristics (number of adults, number of employees, number of children, income, number of vehicles);

CD = a household's commute distance;

WA = a vector representing the accessibility of the workplace (regional and neighborhood);

RA = a vector representing the accessibility of the residence (regional and neighborhood).

Number of tours, tour complexity

To establish relationships between accessibility and tour generation, this research is guided by the threshold hypothesis (Adler & Ben-Akiva 1979) suggesting that unfulfilled household activities accumulate until some critical threshold is reached. At this threshold, a tour is scheduled to complete some or all of the activities. More tours would therefore be expected in areas with higher NA because the cost (in terms of time and inconvenience) would be less for each. The corollary states that the complexity of each tour would decrease. The subsequent hypothesis is that (a) increases in NA would be directly related with increased tour generation, and (b) increases in accessibility would be directly related with a decreased propensity to link trips (decreased trips per tour).

Results from two models testing these hypotheses are shown together with their estimated coefficients and other statistical indicators in Table 6. Models predicting number of tours is estimated as a poisson regression because of the count nature of the data; models predicting number of trips per tour and tour distance (averaged over the household) are estimated using OLS regression because of the continuous nature of the data. As expected, variables representing household characteristics (number of adults, number of employees, number of children) are statistically significant and positive for tour generation. Conversely, the same variables for household characteristics are significant

Table 6. Regression results for tour number and trips per tour.

Outcome variable / Explanatory variable	Number of tours (poisson regression)			Number of trips per tour (OLS regression)		
	Coefficient	*t*-stat	Signif	Coefficient	*t*-stat	Signif
(Constant)	0.4003	8.499	0.000	3.411	32.484	0.000
# of adults	0.4061	23.034	0.000	–0.137	–2.917	0.004
# of employees	3.01E-02	1.792	0.073	–8.571E-02	–2.064	0.039
Household income	2.50E-06	4.787	0.000	2.720E-06	2.208	0.027
# of vehicles	1.57E-02	1.505	0.132	–7.882E-03	32.484	0.766
# of older children	0.2053	18.766	0.000	–2.511E-02	–0.830	0.406
Commute distance	–3.93E-03	–2.859	0.004	–4.521E-03	–1.425	0.154
Work neigh. access	4.59E-02	2.532	0.011	8.381E-02	2.044	0.041
Work reg. access	–4.00E-06	–1.368	0.171	1.279E-05	1.914	0.056
Residential neigh. access	0.1212	6.148	0.000	–0.129	–2.841	0.005
Residential reg. access	–7.56E-06	–1.377	0.169	–1.126E-05	–0.914	0.361
n = 1,811 households	Log likeihood function At convergence: –3873.813 Initial: –4724.961 Pseudo $\sigma^2 = 0.18$			Adj. $R^2 = 0.028$ $F = 6.268$, $P < 0.000$		

and inversely related to tour complexity; the greater the number of adults, employees, and children the less likely the household linked trips. This is likely because more people per household reduce the burden of chores on anyone individual – and subsequently the trip chaining for any single individual. Commute distance was significant and negative for tour generation, showing that households with longer commute distances engage in fewer tours. The impact of commute distance on tour complexity, however, was not significant. The impact of NA also shows to be statistically significant and in the expected direction for each model. Households with higher NA make more tours. The model for number of trips per tour shows that tour complexity is inversely related to levels of NA; households who live in areas with higher NA are more likely to make tours with a fewer number of stops.

Tour frequency by purpose

Models of tour frequency and tour complexity, however, do not shed light on trip purpose – an important issue since maintenance trips are likely to vary based on differing levels of NA. (The previous discussion suggests that maintenance activities would be pursued as part of a tour closer to home since these types of trips could be more easily satisfied local to one's neighborhood.) To test hypotheses that different types of tours are likely to vary be levels of NA, regression models predict the frequency in which households engage in each of the nine different tour types (Table 7). Of the nine different tour types modeled, the measure of residential NA proved significant and positive in only two. Not surprisingly, these models represent two types of simple tours – subsistence and maintenance. The models generated for the remaining seven tour types had exceptionally low explanatory power from a statistical standpoint and/or the measure of NA was not statistically significant at the 90% level. Simple commute tours were likely significant because households living in high NA return home directly from work before heading out again in the evening. The increased number of simple maintenance tours is entirely consistent with the arguments presented thus far.

In theory, we could expect that households in high NA areas to more likely engage in at least two other types of tours. The first would be complex maintenance-only tours – multiple errands combining grocery, dry cleaner, and bakery within walking distance of one's residence. The second type of tour would represent combined subsistence-maintenance tours: commuting by transit and stopping at the neighborhood store on the way home to pick up groceries. These would be the showcase tours that the new urbanists love to point to.

The findings, however, suggest that NA appears to have little influence on a household's propensity to engage in complex tours of any kind. This is likely because of two related reasons. First, consider the above mentioned

Table 7. Regression results for frequency of tour type.

Outcome variable / Explanatory variable	Number of simple work tours (tour type 1)			Number of simple maint tours (tour type 2)		
	Coefficient	*t*-stat	Signif	Coefficient	*t*-stat	Signif
(Constant)	0.232	3.672	0.000	0.289	4.284	0.000
# of adults	9.21E-02	–3.242	0.001	0.197	6.484	0.000
# of employees	0.337	13.319	0.000	–0.205	–7.580	0.000
Household income	–2.73E-06	–3.653	0.000	1.11E-07	0.139	0.889
# of vehicles	2.41E-02	1.494	0.135	–3.47E-02	–2.010	0.045
# of older children	–5.49E-03	–0.297	0.767	0.199	10.043	0.000
Commute distance	3.267E-03	3.672	0.089	–1.32E-03	–0.647	0.518
Work neigh. access	0.105	4.169	0.000	–4.55E-02	–1.702	0.089
Work reg. access	–1.38E-05	–3.380	0.001	3.50E-06	0.803	0.422
Residential neigh. access	6.97E-02	2.523	0.012	0.120	4.077	0.000
Residential reg. access	8.93E-06	1.187	0.235	–1.19E-05	–1.489	0.137
n = 1,811 households	Log likeihood function At convergence: –2554.355 Initial: –3104.018 Pseudo σ^2 = 0.17			Log likeihood function At convergence: –2540.955 Initial: –2864.248 Pseudo σ^2 = 0.10		

tour that combines subsistence and maintenance stops. It is conceivable that residents in high NA areas complete maintenance errands by foot on the way home from using transit. Households in areas with low NA may perform the same errands in the same order, but would do so driving from one neighborhood to another. Second, there remain a limited range of services in highly accessible neighborhoods; these services more likely satisfy maintenance type activities than subsistence and discretionary activities. Therefore, any tour containing a work or leisure trip is *less* likely to be pursued locally. Satisfying these purposes is more likely to pull the traveler beyond the range local to one's neighborhood. Households who live in high or low NA have an equal propensity of leaving their neighborhood to complete trips for subsistence or discretionary purposes; once they leave the neighborhood for these other types of services, there is similar likelihood of chaining trips.

Distance for simple maintenance tours

Because of the theoretically important role of maintenance travel, the final part of this analysis focuses on simple maintenance tours to gain a better understanding of the extent to which access affects the nature of these tours. The final column of Table 5 presents descriptive statistics for the mean distance for each of the nine tour types. As expected, simple tours (only two trips per tour) show shorter distances; specifically, maintenance-only tours are shortest.

The mean values reported are from a univariate distribution of households spread throughout the region with varying degrees of neighborhood access. Some households can satisfy maintenance errands close to their residence, others must drive considerable distances for basic services. To better test the effect of NA on travel across this univariate distribution, it is important to determine the extent to which the distance traveled for simple maintenance tours (tour type #2) is inversely related to levels of NA (Table 8). As expected, the coefficient for NA is significant and negative indicating higher levels are met with shorter tour distances. The relative importance of the factors influencing tour distance is summarized in the results of an effect analysis shown in the last column. Neighborhood access appears to impact tour distance more than any variable (other than the number of older children). However, increasing its value from the median value to the 75th percentile results in only a ten percent reduction in tour distance. This suggests that while NA does impact simple maintenance tour distance, it draws into question the influence of land use planning and in particular, how often maintenance services are captured internal to the neighborhood. Table 9 therefore provides detailed descriptive statistics for maintenance-only travel; results are presented across

Table 8. Regression results distance of for tour number and trips per tour.

Outcome variable / Explanatory variable	Distance of simple maintenance tours (ln) (OLS)			
	Coefficient	*t*-stat	Signif.	Effect analysis*
(Constant)	15.115	10.077	0.000	
# of adults	0.610	0.936	0.350	n.s.
# of employees	–0.729	–1.325	0.186	n.s.
Household income	1.70E-05	1.034	0.301	n.s.
# of vehicles	0.650	1.640	0.101	n.s.
# of older children	–1.43	–2.935	0.003	–21%
Commute distance	0.192	4.238	0.000	12%
Work neigh. access	–1.150	–1.996	0.046	–6%
Work reg. access	–1.58E-05	–0.162	0.871	n.s.
Residential neigh. access	–3.513	–5.461	0.000	–15%
Residential reg. access	–3.38E-04	–1.897	0.058	–5%
n = 1,811 households	Adj. R^2 = 0.162 F = 18.91, P < 0.000			

* shows the percentage change in the dependent variable that would result if the score for the independent variable increased from the median value to the value at the 75th percentile of all observations, substituting median values for other variables in the regression equation (e.g., change in # of children, from 0 to 2; change in commute distance, from 7.4 to 14.1).

Table 9. Descriptive statistics for maintenance trips/tours for neighborhoods with high and low neighborhood accessibility.

		Entire sample	Households in *upper* decile (10%) of neighbor-hood access	Households in *lower* half (50%) of neighbor-hood access
Distance of simple maintenance tours	Median	11.9 (6.0)*	6.44 (3.2)*	16.1 (8.1)*
	Mean	18.1 (9.1)*	9.9 (5.0)*	2.2 (11.1)*
	Std. dev.	20.8	10.8	21.3
		(*n* = 2,150)	(*n* = 181)	(*n* = 1,047)
Distance of maintenance trips	Median	6.3	3.9	7.9
	Mean	9.8	6.4	11.6
	Std. dev.	11.2	8.7	11.4
		(*n* = 10,008)	(*n* = 931)	(*n* = 5,030)
Percentage of simple, maintenance tours completed within . . .	3.2 km	4.5%	20%	1.7%
	4.8 km	13%	38%	5.4%
	6.4 km	22%	50%	12%

* 1 km = 0.62 mi / * each way.
Maintenance trips include personal, appointment, and shopping.

the univariate distribution as well as for bifurcated distributions of households who live in both the lower half and the upper decile (10%) of accessible neighborhoods.[6]

Examining median values, we see expected differences in travel distance. Households with high NA travel 3.2 km (2.0 mi) one-way for maintenance activities versus the 8.1 km (5.0 mi) one-way distance for households with lower NA. The differences in median distance – 3.2 km versus 8.1 km – supports the expected hypothesis for high versus low NA. But a distance of 3.2 km is hardly the walking distance espoused by new-urbanists and other like minded advocates. It is therefore helpful to know how such trips are distributed for these two populations. Households in highly accessible neighborhoods complete 20% of their simple maintenance tours within 3.2 km of their home. This is compared to a mere 1.7% of simple maintenance tours for their low NA counterparts. While a distance of 3.2 km (2.0 mi) is still being beyond walking distance, it needs to be recognized that this represents a median value.

Summary, conclusions, and policy significance

Land use and transportation planners have been increasingly interested in better understanding relationships between urban form and household travel behavior. Embedded within this inquiry, at least two specific questions remain outstanding. First, how do NA and trip purpose relate? Second, how do NA and the manner in which such trips are combined – travel tours – relate? Most studies are unable to shed light on these questions because they employ only a trip-based approach to operationalize travel. Failing to examine the pattern of linked travel does not consider relationships that may exist between trip frequency, trip chaining and subsequently, the decision making process of how individuals make travel decisions.

To further clarify how urban form and travel relate, this paper first describes different trip purposes likely to be influenced by neighborhoods with high NA. Second, it introduces and employs a tour-based framework to analyze relationships between NA, the number of tours, types of tours, and tour distance. Crudely simplified, the findings suggest that households in higher levels of NA tend to leave home more often, but they tend to make fewer stops when they do. Of the nine classified tour types, these households more frequently engage in two of them: simple subsistence and simple maintenance. While higher NA households travel shorter distances for maintenance-type errands (personal, appointment, and shopping), the findings suggest that a large portion of their maintenance travel is still pursued outside the neighborhood; a mere 20 percent of their simple maintenance tours are within 3.2 km (2.0 mi) of their home (in contrast to a mere 1.7 percent for households in the lower half of neighborhood accessibility). Thus, the often touted VMT savings of living close to services appears to be negligible because this represents only a fraction of maintenance travel, much less all travel.

These findings are important because this phenomena was tackled head-on for the first time and found weak results. While the research produced statistically significant models, the relatively low *R*-squared values suggest there remains a considerable amount we do not know about predicting travel behavior using cross-sectional data study (although, *R*-squared values to predict travel behavior rarely exceed 0.3). These findings are confounded by a variety of factors. What remains relatively unclear from this research is whether: (a) maintenance tours substitute or complement other trips, (b) maintenance tours tend to be pursued by non-motorized mode, and (c) the majority of these tours are conducted local to one's neighborhood.

For land use and transportation policy, several issues are important. Primary among them is whether maintenance travel (what has often been called non-work travel) is captured within areas of high NA. The results of this research suggest that this relationship is not nearly as strong as Smart Growth advocates contend. Many households, even those living in high NA areas, will continue to shop outside their immediate neighborhood. Maintenance-type errands are subject to the demands of consumer behavior – e.g., bargain hunting, comparison shopping, preference for variety, parking convenience – each of which prize destination and schedule flexibility (Nelson & Niles 1998). A household's desired good at the desired price is often not located within walking distance to home. Basic preferences suggest that households will travel farther than their neighborhood center for many basic shopping needs. Each of these factors are likely to draw the shopper away from the neighborhood. While households with high NA may frequent the corner store periodically, it does not take but a few maintenance trips across town to boost the median distance. In some respects quantitative analysis may be inappropriate to shed light on the subtle nuances of travel behavior decisions. A more qualitative mode of inquiry is likely necessary to better explain tradeoffs related to substitution travel, mode choice, or local travel (Handy & Clifton 2001).

Ultimately, the enormous complexity between attitudes, household behavior, preferences and social and economic constraints make definitive progress on this front extremely difficult. Perhaps this study's greatest contribution is that it identifies an important – yet often glossed over – relationship between household travel and levels of access. Given increasing debate concerning the capacity of alternative land use planning as a means of travel demand, it is important for both planners and decisionmakers to recognize the nature of household trip making *vis-à-vis* the services usually contained within areas of high NA. A more thorough understanding will ultimately aid policy makers construct better informed policies about the built environment.

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Notes

1. It is important to point out that the thrust of such designs aim primarily, though not exclusively, to increase access to non-work related activities (e.g., convenience stores and the like) as opposed to work-related activities (e.g., employment centers and the like).

2. A more detailed breakdown by four digit SIC code would be preferred because it more cleanly filters services typically available in areas with high NA. However, issues of confidentiality required only two-digit SIC code data to be released for this research. To filter for potentially large businesses that run counter to NA principles (e.g., Costco, Home Depot), but may be included in the same classification, no establishment with greater than 200 employees is included. A common issue with such data is that many businesses attribute employees in remote (or sub) locations to a single payroll office (e.g., janitorial services, temporary employment agencies). The author manually checked the extent of this issue to verify that it was not a significant problem of note in the Seattle area for the four identified employment types.
3. The panel consisted of five academics from the fields of urban planning, urban design, geography, public affairs, and transportation and was representative of a group of experts familiar with the concept of accessibility and urban form. They were selected based on two criteria: (1) their extensive spatial knowledge of the Puget Sound region, and (2) their knowledge of the basic tenets of urban form and neighborhood access. The first criteria was particularly valuable in the panel's ability to assess specific housing locations.
4. The subjectively assigned NA score was regressed using OLS on the three independent variables for 70 cases and revealed an F-stat of 63.62 (p = 0.000). Each of the three independent variables were logarithmically transformed and significant at the 0.02 level or less with the following coefficients: housing density (0.514), block size (–0.227), land use mix (0.242). Given the nature of the dependent variable, however, an ordered probit model is technically preferred and was modeled using LIMDEP software. Each of the transformed variables were significant at the following levels – density (0.002), block size (0.133), land use mix (0.002) – with the model revealing a psudeo σ^2 of 0.41.
5. While activity frequency is most often conducted on an individual level, decisions about travel are conducted at both the individual and the household level, leading to a fundamental tension between the appropriate unit of analysis. For this analysis, the household level tends to be more appropriate because it is the level in which many of the longer term decisions are made such as residential location and/or number of vehicles. Furthermore, using the household level data is better able to capture the complexity and tradeoffs embedded within the shorter-term decisions such as activity and travel. These travel decisions are often a reflection of the inter-household bargaining that may exist with respect to chores, errands, and/or available time.
6. The upper decile was chosen because areas above this threshold were considered to contain representative characteristics of high NA. Using other thresholds (e.g., quartiles) included area that did not attain the urban form "feel"promoted by high levels of NA, despite having relatively high NA scores.

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