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Neighborhood Design and Vehicle Type Choice: Evidence from Northern California

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Abstract

Previous studies have found that suburban development is associated with the unbalanced choice of light duty trucks (LDTs). However, the specific aspects of the built environment that influence vehicle choice have not been well-established. Further, these studies have not shed much light on the underlying direction of causality: whether neighborhood designs themselves, as opposed to preferences for neighborhood characteristics or attitudes towards travel, more strongly influence individuals' decisions regarding vehicle type. Using a sample from Northern California, this study investigated the relationship between neighborhood design and vehicle type choice, controlling for residential self-selection. Correlational analyses showed that neighborhood design has a strong association with vehicle type choice. Specifically, traditional neighborhood designs are correlated with the choice of passenger cars, while suburban designs are associated with the choice of LDTs. The nested logit model suggests that sociodemographic and attitudinal factors play an important role, and that an outdoor spaciousness measure (based on perceptions of yard sizes and off-street parking availability) and commute distance also impact vehicle type choice after controlling for those other influences. Therefore, this study supports the premise that land use policies have at least some potential to reduce the choice of LDTs, thereby reducing emissions.

Key words: air quality, land use, nested logit model, self-selection, smart growth

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1. Introduction

Air pollution, greenhouse gas emissions, and oil dependence are major concerns in the U.S. One factor is the increasing share of light-duty trucks (LDTs, including minivans and pickup trucks as well as sport utility vehicles (SUVs)) in the passenger vehicle fleet, which contributes to these problems due to the differential fuel efficiency and emissions standards between passenger cars and LDTs. According to the 2004 Fuel Economy Guide (www.fueleconomy.gov), for example, on average a 2WD Ford F150 (a pickup truck) consumes 35% more gasoline per mile than a Ford Taurus (a passenger car), and produces 30% more greenhouse gases and 200% more air pollutants. Another factor is suburban development, widely criticized for its contribution to longer average trip lengths and excessive dependence on private vehicles at the expense of public transit and non-motorized modes. Accordingly, a "smart growth" approach to planning has been proposed as a counter to urban sprawl. Previous studies have concluded that compact development and integration of land uses can lower auto ownership, reduce trip lengths, and increase the uses of alternative modes (e.g., Cervero and Radisch, 1996; Chu, 2002; Frank et al., 2000). The EPA now recognizes land-use policies as an effective tool for improving air quality and allows state and local communities to account for the air quality benefits of smart growth strategies in State Implementation Plans (SIPs) as a part of the Voluntary Mobile Source Emission Reduction Program (EPA, 2001).

A few recent studies have found that suburban development is associated with the unbalanced choice of LDTs. For example, an analysis of the 1995 Nationwide Personal Transportation Survey (NPTS) showed that suburban residents own a disproportionate share of LDTs (Niemeier et al., 1999). After examining data from the San Francisco Bay Area, Bhat and Sen (2006) found that households living in denser areas are less inclined to drive SUVs and pickup trucks. However, these studies seldom reveal which specific characteristics of the built environment matter to vehicle type choice. Further, they have not shed much light on the underlying direction of causality: in particular, whether neighborhood designs themselves, as opposed to preferences for neighborhood characteristics or attitudes towards travel, more strongly influence individuals' decisions regarding vehicle type. The available evidence thus leaves unanswered questions: if policies encourage more compact development, will more people choose to drive passenger cars over LDTs, with a corresponding benefit to air quality?

The purpose of this study is to investigate the role of neighborhood design in vehicle type choice using a sample from Northern California. This paper addresses the following questions: (1) What aspects of neighborhood design influence vehicle type choice? (2) Controlling for sociodemographic traits, what is the role of residential preferences and travel attitudes in vehicle type choice? Answering these questions helps us answer the ultimate question of interest: Can land use policies contribute to air quality improvement by influencing vehicle type choice? The next section reviews the literature relevant to vehicle type choice. Section 3 describes the data and variables used in this study. Section 4 presents analysis of variance

(ANOVA) results relating vehicle type choice to neighborhood design, attitudes, and sociodemographics. A nested logit model of vehicle type choice is discussed in Section 5. The final section recapitulates the key findings and discusses some policy implications of the results.

2. Literature Review

A number of studies have investigated households' or individuals' vehicle type choices (e.g., Beggs and Cardell, 1980; Berkovec and Rust, 1985). Their main interests focused on vehicle attributes (such as purchasing and operating costs, horsepower, and scrappage) and household characteristics (such as household structure and income), in order to identify the factors that impact consumers' vehicle-purchasing or holding behavior. These studies highlighted that households' sociodemographics are primary determinants of their vehicle type choices. Further, it was found that vehicle type choice strongly depends on drivers' travel attitudes, personality, and lifestyle (Choo and Mokhtarian, 2004). However, whether neighborhood design provides an incremental contribution to vehicle choice has seldom been explored.

A few recent studies have pointed to this question. A correlational analysis found that the percentage of households with LDTs decreases as residential density increases in the 2001 National Household Transportation Survey (NHTS) data (Golob and Brownstone, 2005). However, this relationship may be confounded by sociodemographics. For example, more affluent households may choose to live in large-lot houses in suburban neighborhoods and drive SUVs at the same time. Using the 1995 NPTS data, Kockelman and Zhao (2000) found that LDTs were more often driven by households living in lower density areas, after accounting for the influences of sociodemographics. On the surface, these findings seem to suggest that neighborhood design influences vehicle type choice, with traditional neighborhood residents favoring passenger cars and suburban residents favoring LDTs. Therefore, suburban development might be further blamed for its contribution to the disproportionate growth of low-efficiency and high-emission LDTs.

However, researchers recognize that density is a coarse measure of neighborhood design due to its high correlation with other neighborhood characteristics such as parking and transit service, and hence its theoretical connection with travel choice is not clear (Handy, 2005). Thus, what is it about suburban development that results in choices of LDTs? Low accessibility? Segregated use? Availability of space for parking? All of these, none of these, or some combination? Without an understanding of what the influential characteristics are, policy makers and city planners have little guidance on how to potentially affect vehicle choice through neighborhood design. Therefore, it is important to address how individual elements of neighborhood design and their integration might influence vehicle choice, rather than simply comparing the impacts of traditional and suburban developments. Kitamura et al. (2001) found that accessibility (as well as various density measures) influences vehicle type choice in the Los Angeles metropolitan area, controlling for sociodemographics. Specifically, auto accessibility has a negative association with choosing sport cars, transit accessibility is negatively associated with the choice of SUVs, and sedans are less likely to be chosen in areas where public transit is not available. However, what are the underlying mechanisms by which accessibility and other neighborhood characteristics affect vehicle type choice? The limited number of studies conducted to date have not fully enlightened our understanding of the relationships between neighborhood design and vehicle type choice.

Further, it is not clear whether the observed associations can be attributed to the influence of living in an urban area on the decision to buy a passenger car, or to a correlation between preferences for passenger cars and preferences for urban environments, or the combined effects of these two factors. Previous studies have found associations between neighborhood design and vehicle type choice. However, an association does not mean a causal relationship. To infer causality, scientific research generally requires at least three kinds of evidence: association, time precedence, and nonspuriousness (Singleton and Straits, 2005). Given cross-sectional data, however, it is hard to determine time precedence. A nonspurious relationship between variables refers to an association that cannot be explained by an antecedent variable. In this context, some variables such as attitudes and sociodemographics are probably causal factors for the choices of both neighborhood design and vehicle type (Figure 1). Therefore, the observed correlations between neighborhood design and vehicle type choice may be partially spurious, caused by the antecedent variables. Empirically, Choo and Mokhtarian (2004) found that those preferring denser neighborhoods were more likely to drive passenger cars (but also SUVs), lending at least some support to the self-selection speculation. To establish nonspuriousness, an appropriate strategy is to examine the effects of neighborhood design, controlling for antecedent variables (Singleton and Straits, 2005). Therefore, incorporating attitudinal factors in addition to sociodemographics in the model will help clarify the relationships between neighborhood design and vehicle type choice.

[Insert Figure 1 here]

3. The Data and Variables

3.1 Data

The data used in this study came from a self-administered survey mailed in two rounds in late 2003 to residents of eight neighborhoods in Northern California. The neighborhoods were selected to vary systematically on neighborhood type, size of the metropolitan area, and region of the state. Neighborhood type was differentiated as “traditional” for areas built mostly in the pre-World War II era, and “suburban” for areas built more recently. Using data from the U.S. Census, we screened potential neighborhoods to ensure that average income and other characteristics were near the average for the region. Four neighborhoods in the San Francisco Bay Area, including two in the Silicon Valley area and two in Santa Rosa, had been previously studied (Handy, 1992). In the Central Valley region, two neighborhoods from Sacramento and two from

Modesto were selected to contrast with Bay Area neighborhoods. The four traditional neighborhoods differ in visible ways from the four suburban neighborhoods – the layout of the street network, the age and style of the houses, and the location and design of commercial centers.

For each neighborhood, we purchased two databases of residents from a commercial provider, New Neighbors Contact Service (www.nncs.com): a database of "movers" and a database of "nonmovers." The "movers" included all current residents of the neighborhood who had moved within the previous year. From this database, we drew a random sample of 500 residents for each of the eight neighborhoods. The database of "nonmovers" consisted of a random sample of 500 residents not included in the "movers" list for each neighborhood.

The original database consisted of 8000 addresses but only 6746 valid addresses. The response rate is about 25% based on the valid addresses only. This response rate is considered quite good for a survey of this length, since the response rate for a survey administered to the general population is typically 10-40% (Sommer and Sommer, 1997). A comparison of sample characteristics to population characteristics, based on the 2000 U.S. Census (Table 1), shows that survey respondents tend to be older than residents of their neighborhood as a whole, and that the percent of households with children is lower for the sample for most neighborhoods. In addition, median household income for survey respondents was higher than the census median for all but one neighborhood, a typical result for voluntary self-administered surveys. However, since the focus of our study is on explaining vehicle type choice as a function of other variables rather than on describing the simple univariate distribution of vehicle type choice *per se*, these differences are not expected to materially affect the results (Babbie, 1998).

[Insert Table 1 here]

3.2 Variables

The dependent variables are the possible categories for the vehicle that a respondent drove most frequently. These vehicles were classified into four categories: passenger car, minivan, SUV, and pickup truck, based on reported make, model, and year combinations. As shown in Table 2, there are some distinctions in vehicle type choice between traditional and suburban neighborhoods – residents living in suburban neighborhoods more frequently drive minivans and pickup trucks. On the other hand, contrary to Kitamura et al. (2001), there is no difference in the share of SUVs between traditional and suburban neighborhoods.

[Insert Table 2 here]

The explanatory variables were grouped into five categories, as follows.

Neighborhood characteristics and neighborhood preferences: Respondents were asked to indicate how true 34 characteristics are for their neighborhood, on a four-point scale from 1 ("not at all true") to 4 ("entirely true"). The characteristics of these neighborhoods as perceived by survey respondents reflect fundamental differences in neighborhood design. Further, the importance of these items to respondents when/if they were looking for a new place to live were measured on a four-point scale from 1 ("not at all important") to 4 ("extremely important"). A factor analysis on perceptions and preferences of neighborhood characteristics reduced these items (after dropping some) to six factors: accessibility, physical activity options, safety, socializing, attractiveness, and outdoor spaciousness (Table 3). Commute distances, a measure of proximity of employment and residential locations, were also measured in the survey.

[Insert Table 3 here]

Following the survey, objective measures of accessibility were estimated for each respondent, based on distance along the street network from home to a variety of destinations classified as institutional (bank, church, library, and post office), maintenance (grocery store and pharmacy), eating-out (bakery, pizza, ice cream, and take-out), and leisure (health club, bookstore, bar, theater, and video rental). Accessibility measures included the number of different types of businesses within specified distances (a mixed-use indicator), the distance to the nearest establishment of each type, and the number of establishments of each business type within specified distances. Commercial establishments were identified using on-line yellow pages, and ArcGIS was used to calculate network distances between addresses for survey respondents and commercial establishments. In the context of the present study, all these measures should be viewed generally as indicators of accessibility and land use mix. It is those general characteristics of a neighborhood that might be expected to influence vehicle type choice, rather than the specific land use types themselves.

Travel attitudes: To measure attitudes regarding travel, the survey asked respondents whether they agreed or disagreed with a series of 32 statements on a 5-point scale from 1 ("strongly disagree") to 5 ("strongly agree"). Factor analysis was then used to extract the relatively uncorrelated fundamental dimensions underlying these 32 items. As shown in Table 4, six underlying dimensions were identified: pro-bike/walk, pro-transit, pro-travel, travel minimizing, car dependent, and safety of car.

[Insert Table 4 here]

Travel behavior: The survey also asked respondents to report their weekly vehicle miles driven (VMD), a reflection of their mobility needs. In the data, passenger car drivers on average drive 158 miles per week while LDT drivers drive more than 183 miles per week (difference significant at the 0.01 level).

Sociodemographics: Finally, the survey contained a list of sociodemographic variables that may help to explain respondents' vehicle choice decisions. These variables include gender, age, employment status, education, household income, household size, the number of children in the household, mobility constraints, residential tenure, and so on.

3.3 Hypotheses for neighborhood characteristics

Sociodemographic variables (e.g., income and household size) are widely understood to affect vehicle type choices, and attitudes, although less often measured, are also expected to affect them. In addition to sociodemographics and attitudes, we hypothesize that neighborhood design further contributes to explaining variations in vehicle type choice. However, since the survey was originally developed to explore the relationship between neighborhood design and travel behavior, not all neighborhood characteristics presented above have meaningful connections with vehicle type choice. For example, neighborhood attractiveness is a good predictor for pedestrian travel (Handy et al., forthcoming), but it may have nothing to do with vehicle choice. For this study, we speculate that vehicle type choice is influenced by outdoor spaciousness and commute distance, and that the various measures of accessibility (including land use mix and number of opportunities) are proxies for other factors.

Compared to passenger cars, a larger space is generally required to accommodate LDTs. Therefore, we assume that outdoor spaciousness has a positive association with LDT choices. Specifically, off-street parking is more able to accommodate large vehicles; the driveway associated with large front yards and large back yards (if rear parking) offers a common alternative to park LDTs. Commute distance is hypothesized to have the potential to influence vehicle type choice. In contrast to most non-work activities, the commute is a necessary and spatially constrained trip for workers. A long commute may encourage individuals to use a more fuel-efficient vehicle (passenger car), or conversely it may encourage individuals to buy a larger vehicle which they perceive to be safer and/or more comfortable.

Lower accessibility and segregated uses are assumed to be associated with the choice of LDTs. In particular, living in a lower-accessibility area can be a surrogate for larger lot and housing sizes, and people living in such an area may have more of a need for LDTs owing to larger gardens and greater home improvement demands. This association between lower accessibility and choice of LDT may also be due in part to the higher proportion of home ownership in such neighborhoods (given that home owners are more likely to conduct improvement projects than renters are), although home owners in higher-accessibility as well as lower-accessibility neighborhoods may require a larger-capacity vehicle. Further, towing is one of the fundamental functions of pickup trucks and SUVs, and they are advertised as powerful vehicles operating in rugged environments. Therefore, residents in lower-accessibility (although more especially rural) areas may be more likely to choose those vehicles, with residential location serving partly as a proxy for attitudes, and partly as an indicator of greater need for such a vehicle.

4. Correlational Analyses

One-way ANOVA was used to identify significant differences among the four vehicle categories at the 0.05 level. Once we found the existence of significant differences, Bonferroni pairwise comparison tests were used to further identify which categories are significantly different from other categories.

As shown in Table 5, drivers of different categories of vehicles live in areas with different neighborhood characteristics. First, as expected, accessibility (measured in several different ways) is related to vehicle type choices. Vehicle type choices are significantly associated with the number of business types, maintenance, leisure, and eat-out businesses within 800 meters of the residence. The Bonferroni test suggests that compared to minivan and pickup drivers, passenger car drivers are more likely to live in high-accessible areas. On average, passenger car drivers live closer to various types of businesses than do the drivers of one or more LDT categories. Also, passenger car drivers tend to perceive a higher accessibility than pickup drivers. Second, also as hypothesized, SUV and pickup drivers are more likely to live in areas with large yards and off-street parking than are passenger car drivers. In addition, SUV and pickup drivers tend to live farther from their employment locations than do passenger car drivers. This finding is opposite to our expectation with respect to the choice of more fuel-efficient vehicles, but consistent with other evidence associating minivan and pickup drivers with suburban locations, which in turn are associated with longer commutes. Generally, most differences observed in neighborhood design are between passenger cars and LDTs, especially minivans and pickup trucks. These results suggest that minivans and pickup trucks tend to be associated with a suburban culture while SUVs fit both urban and suburban cultures.

[Insert Table 5 here]

However, the causality between neighborhood design and vehicle type choice is not straightforward. It is possible that self-selection is at work. A further examination of attitudinal factors somewhat supports this argument. To begin with, when looking for a place to live, LDT drivers think that large yards and off-street parking are more important than do passenger car drivers. That is, these drivers may have preferred more space to accommodate their large LDTs and consciously chose such a residence. Further, travel attitudes influence vehicle type choice. SUV drivers are more likely to prefer walking and biking than are passenger car drivers, while pickup drivers have less favorable views of public transit as a mode of transport. SUV and pickup drivers are more likely than others to believe that a car is safer than other modes of transportation. In addition, passenger car drivers have a greater tendency to minimize their travel than do pickup drivers. These results suggest that attitudes may play a more direct role in the choice of LDTs than does neighborhood design.

Further, several sociodemographic characteristics are associated with vehicle type choice. Less-educated people have a higher probability of driving pickups than do their more highly-educated counterparts. Individuals with higher household incomes have a greater tendency to drive SUVs than passenger cars and pickups. Compared to the other three categories, minivans are more likely to be driven by larger households, and those in larger households are more likely to drive SUVs than passenger cars. In addition, chi-squared tests show that housing tenure and gender are significantly associated with vehicle type choices, with home renters favoring passenger cars and men favoring pickups. Since larger households are more prevalent in the suburbs and renters are more prevalent in traditional neighborhoods (as shown for these data by Table 1), it may be that the greater popularity of minivans in the suburbs and greater prevalence of passenger vehicles in traditional neighborhoods (shown in Table 2) are entirely due to sociodemographic factors rather than to neighborhood design per se.

Given the existence of multiple confounded effects, it is hard to tell which effect is dominant through pairwise relationships alone. Accordingly, it is necessary to employ multivariate analysis to investigate the effects of neighborhood design on vehicle type choices, controlling for attitudes and sociodemographics.

5. Modeling Vehicle Type Choice

Since the dependent variable consists of four nominal categories and some categories share common characteristics, we attempted to estimate various nested logit (NL) models for vehicle type choice using Limdep 8.0 (Figure 2). The inclusive value (IV) parameters for most of these models were either outside the permitted range (i.e., greater than 1) or not significantly different from 1 (i.e., not different from the multinomial logit model). Initial structure NL4 performed the best, but its IV parameter for the pickup-SUV nest was not significantly different from 1 and hence that nest collapsed. The parameter for the car-van nest, however, was estimated at 0.299 and significantly different from 1, so it is that final structure whose model we present in Table 6. Since the fundamental function of both passenger cars and minivans is more to carry passengers than to carry goods, it is reasonable that these two vehicle types share the same nest. In fact, the correlation of unobserved variables for these two alternatives is very high at $1 - 0.299^2 = 0.91$. As shown in Table 6, the ρ^2 of the final model is 0.472, which is quite good for a disaggregate model involving four discrete choices. The χ^2 statistic, for the comparison of the full model to the market share model, is 266.4 and significant at less than the 0.001 level, indicating that the true variables significantly improve the model over one containing the constant terms alone.

[Insert Figure 2 here]

[Insert Table 6 here]

Sociodemographic characteristics significantly affect vehicle type choice. Those who are more affluent and have more children under 18 years old in the household tend to drive SUVs. Men and people with less education are more likely to choose pickup trucks, consistent with Mohammadian and Miller (2003). Those owning more vehicles are also more likely to drive pickup trucks, suggesting that a pickup is often the second, third, or later vehicle acquired in order to diversify the household's transportation options. This result is consistent with Kockelman and Zhao (2000) and Golob and Brownstone (2005). As expected, individuals who are home owners and have more children under 18 years old are more likely to drive minivans. Perhaps surprisingly, age is positively associated with the choice of minivans; the mean age of minivan drivers (48.6) is highest among the four vehicle types. However, this result is consistent with other studies. In the Canadian Automobile Association's 2000 Auto Ownership Survey, the older age group had three minivans among the top 10 vehicles of their dreams, but no minivans were chosen in the top 10 by the younger respondents (Hunt, 2001). Anecdotal explanations for this pattern include the relative ease of getting in and out of a minivan for older people and images of minivans as boring among younger people.

Attitudinal factors play an important role in influencing vehicle type choice. Individuals who prefer living in less accessible areas are more likely to drive minivans and pickup trucks, and those preferring large yards and off-street parking have an inclination for all three types of LDTs. Interestingly, a preference for walking and biking is positively associated with the choice of SUVs and pickup trucks. It is possible that this association results from a preference for outdoor activities of various kinds, which is linked to both a preference for SUVs and pickups and a preference for walking and biking. Further, those vehicle types may be consciously chosen for their capacities to carry cycling, hiking, and camping gear. In any case, this result offers an intriguing paradox in view of the stereotype that walking and biking are good for the environment, while SUVs and pickup trucks are the most fuel-inefficient and polluting of personal vehicles.

By contrast, those who have positive attitudes toward public transit are less likely to choose pickup trucks. It is possible that this association is also spurious and results from a concern for the environment that is positively linked to a preference for transit and negatively linked to driving pickups, which get relatively poor gas mileage. Underlying differences in lifestyle between transit users and pickup drivers might also help to explain this association. In addition, people who think the car is a safer mode are more likely to drive SUVs. One selling point of the SUV is its safety: some studies have found that SUV drivers have a lower percentage of injuries in accidents with passenger cars (Ulfarsson and Mannering, 2004). However, SUVs may not be as safe even for their drivers as those drivers perceive them to be (Kweon and Kockelman, 2003), and they are more dangerous for occupants of other vehicles in an accident (Gayer, 2001).

After accounting for the influences of sociodemographic traits and attitudes, two neighborhood characteristics appear significant in the model. Individuals who live in areas with more space are more likely to drive pickup trucks (significant at the 0.1 level). This finding is consistent with our hypothesis, but the fact that a *preference* for more space has already been accounted for is important. The implication is that availability of parking space *itself* exerts some influence toward choosing a pickup truck. Further, workers living farther from their employment locations are more likely to drive SUVs. It is worth noting that none of the accessibility measures appear in the model when housing tenure, spaciousness, and attitudes are controlled for. This result supports our speculation that their relationships with vehicle type choice are primarily spurious. Given the extensive influence of sociodemographics and attitudinal factors, however, we cannot expect that neighborhood design will heavily determine vehicle type choice; suburban development at most facilitates LDT choices.

6. Conclusions

This study explored the influences of neighborhood design on vehicle type choice. Correlational analyses showed that neighborhood design has a strong association with vehicle type choice. Specifically, traditional neighborhood designs (exhibiting high accessibility and mixed use) are correlated with the choice of passenger cars, while suburban designs (including large yards and off-street parking) are associated with the choice of LDTs, especially minivans and pickup trucks. However, the relationships between neighborhood design and vehicle type choice are confounded by the significant influences of attitudinal and sociodemographic factors: the disproportionate representation of LDTs in suburban neighborhoods is to some extent a result of preferences for suburban environments and the disproportionate representation in the suburbs of the demographic characteristics associated with the choice of LDTs.

The NL model controls for these other influences, and shows that both attitudinal and sociodemographic factors play important roles in vehicle type choice. Number of children, age, income, and gender are significant in the generally-expected ways, as are home ownership, education, and number of vehicles in the household. With respect to attitudes, those who value parking space or devalue accessibility in their residential choice are more likely to drive LDTs; safety of car and pro-walk/bike factors are positively associated with the choice of one or more LDT categories; but individuals favoring public transit have a disinclination for pickup trucks.

Nevertheless, after controlling for attitudinal factors and sociodemographic variables, we found that outdoor spaciousness (a factor based on yard sizes and off-street parking availability) and commute distances were significant. Thus, the built environment appears to play a separate, though modest, role in vehicle type choice: suburban development itself has an incremental impact on encouraging the acquisition of LDTs and hence contributes to the deterioration of air quality. Given the fact that LDT owners drive more miles, on average, than do passenger car drivers (as shown in our data as well as by Kockelman and Zhao, 2000), this contribution is compounded.

This study thus supports the idea that land use policies have at least some potential to reduce the choice of LDTs, thereby reducing emissions. Two approaches might be taken: creating more neighborhoods that offer traditional characteristics associated with lower LDT use, or modifying the characteristics of suburban neighborhoods that are associated with higher LDT use. The success of the former approach depends on the ability of such areas to attract residents who would otherwise live in neighborhoods with suburban characteristics and choose to own LDTs. Recent studies suggest that traditional neighborhoods are undersupplied relative to the demand (Levine, 1998; Levine and Inam, 2004). According to our results, the latter approach would include restrictions on the provision of off-street parking in new suburban developments and efforts to bring more jobs to suburban areas to reduce commute distances. Such strategies might prompt suburban residents to forego LDTs for passenger cars.

Further research, however, should explore in more detail the process by which the built environment exerts an influence of its own on vehicle type choice. One promising approach is to study vehicle transactions after a residential relocation. Changes in vehicle holdings may not happen instantaneously, but they may well happen at natural decision points within a few years of a move. For example, the move from renting an apartment in an urban neighborhood to buying a home in the suburbs may eventually, if not immediately, precipitate the acquisition of a pickup truck for hauling home improvement materials. Conversely, the move from a spacious suburban home to an apartment in a high-density neighborhood may make that pickup seem out of scale and lead one to trade it in for a smaller, more maneuverable automobile. Of course, such scenarios probably involve a number of confounding factors such as changes in income and stage in life cycle together with the residential move, and these must also be controlled for.

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Table 1. Sample vs. Population Characteristics

	Traditional				Suburban			
	Mountain View	SR Junior College	MD Central	SC Midtown	Sunnyvale	SR Rincon Valley	MD Suburban	SC Natomas
Sample Characteristics								
Number	228	215	184	271	217	165	220	182
Percent of females	47.3	54.3	56.3	58.2	46.9	50.9	50.9	54.9
Average auto ownership	1.80	1.63	1.59	1.50	1.79	1.66	1.88	1.68
Age	43.3	47.0	51.3	43.4	47.1	54.7	53.2	45.6
Average HH size	2.08	2.03	2.13	1.78	2.58	2.19	2.41	2.35
Percent of HHs w/kids	21.1	18.6	21.7	8.9	42.4	24.8	25.5	31.9
Percent of home owners	51.1	57.8	75.6	47.0	61.1	68.7	81.0	82.4
Median HH income (k$)	98.7	55.5	45.5	64.2	95.0	49.5	55.5	55.3
Population Characteristics								
Population	5,493	9,886	13,295	7,259	14,973	13,617	19,045	13,295
Age	36.1	36.3	36.5	42.7	35.9	38.3	38.1	31.7
Average HH size	2.08	2.21	2.46	1.79	2.66	2.48	2.51	2.57
Percent of HHs w/kids	19.3	20.3	32.9	12.4	35.3	35.4	34.2	41.7
Percent of home owners	34.3	31.2	58.8	34.3	53.2	63.5	61.4	55.2
Median HH income (k$)	74.3	40.2	42.5	43.8	88.4	49.6	40.2	46.2

Notes: SR = Santa Rosa, MD = Modesto, SC = Sacramento, HH = household

Table 2. Vehicle Type Choice in Traditional and Suburban Neighborhoods

Neighborhood Type	**Vehicle Type**				**p-value**
	Car	Minivan	SUV	Pickup	(χ^2 test)
Suburban	472 (66.1%)	56 (7.8%)	94 (13.2%)	92 (12.9%)	
Traditional	576 (70.8%)	37 (4.6%)	108 (13.3%)	92 (11.3%)	0.032

Table 3. Pattern Matrix for Perceived and Preferred Neighborhood Characteristic Factors

Factor	Statement	Loading
Accessibility	Easy access to a regional shopping mall	0.854
	Easy access to downtown	0.830
	Other amenities such as a pool or a community center available nearby	0.667
	Shopping areas within walking distance	0.652
	Easy access to the freeway	0.528
	Good public transit service (bus or rail)	0.437
Physical Activity Options	Good bicycle routes beyond the neighborhood	0.882
	Sidewalks throughout the neighborhood	0.707
	Parks and open spaces nearby	0.637
	Good public transit service (bus or rail)	0.353
Safety	Quiet neighborhood	0.780
	Low crime rate within neighborhood	0.759
	Low level of car traffic on neighborhood streets	0.752
	Safe neighborhood for walking	0.741
	Safe neighborhood for kids to play outdoors	0.634
	Good street lighting	0.751
Socializing	Diverse neighbors in terms of ethnicity, race, and age	0.789
	Lots of people out and about within the neighborhood	0.785
	Lots of interaction among neighbors	0.614
	Economic level of neighbors similar to my level	0.476
Attractiveness	Attractive appearance of neighborhood	0.780
	High level of upkeep in neighborhood	0.723
	Variety in housing styles	0.680
	Big street trees	0.451
Outdoor Spaciousness	Large back yards	0.876
	Large front yards	0.858
	Lots of off-street parking (garages or driveways)	0.562
	Big street trees	0.404

a. Extraction method: principal component analysis; Rotation method: oblimin with Kaiser Normalization.
b. The extraction of the accessibility and physical activity options factors is independent of the extraction of the other factors.
c. Loading represents the degree of association between the statement and the factor
d. Factor loadings lower in magnitude than 0.33 are suppressed.

Table 4. Pattern Matrix for Travel Attitude Factors

Factor	Statement	Loading
Pro-Bike/Walk	I like riding a bike	0.880
	I prefer to bike rather than drive whenever possible	0.865
	Biking can sometimes be easier for me than driving	0.818
	I prefer to walk rather than drive whenever possible	0.461
	I like walking	0.400
	Walking can sometimes be easier for me than driving	0.339
Pro-Travel	The trip to/from work is a useful transition between home and work	0.683
	Travel time is generally wasted time	-0.681
	I use my trip to/from work productively	0.616
	The only good thing about traveling is arriving at your destination	-0.563
	I like driving	0.479
Travel Minimizing	Fuel efficiency is an important factor for me in choosing a vehicle	0.679
	I prefer to organize my errands so that I make as few trips as possible	0.617
	I often use the telephone or the Internet to avoid having to travel somewhere	0.514
	The price of gasoline affects the choices I make about my daily travel	0.513
	I try to limit my driving to help improve air quality	0.458
	Vehicles should be taxed on the basis of the amount of pollution they produce	0.426
	When I need to buy something, I usually prefer to get it at the closest store possible	0.332
Pro-Transit	I like taking transit	0.778
	I prefer to take transit rather than drive whenever possible	0.771
	Public transit can sometimes be easier for me than driving	0.757
	I like walking	0.363
	Walking can sometimes be easier for me than driving	0.344
	Traveling by car is safer overall than riding a bicycle	0.338
Safety of Car	Traveling by car is safer overall than riding a bicycle	0.489
	Traveling by car is safer overall than walking	0.753
	Traveling by car is safer overall than taking transit	0.633
	The region needs to build more highways to reduce traffic congestion	0.444
	The price of gasoline affects the choices I make about my daily travel	0.357
Car Dependent	I need a car to do many of the things I like to do	0.612
	Getting to work without a car is a hassle	0.524
	We could manage pretty well with one fewer car than we have (or with no car)	-0.418
	Traveling by car is safer overall than riding a bicycle	0.402
	I like driving	0.356

a. Extraction method: principal component analysis; Rotation method: oblimin with Kaiser Normalization.
b. Loading represents the degree of association between the statement and the factor
c. Factor loadings lower in magnitude than 0.33 are suppressed.

Table 5. One-way ANOVAs for Vehicle Type Choice

Categories	Variables	Vehicle Type				p-value
		Car	Minivan	SUV	Pickup	
Objective Neighborhood Characteristics	# business types within 800 meters	6.00 [Van, Pickup] [a]	4.44 [Car]	5.57	5.02 [Car]	<0.001
	# maintenance businesses within 800 meters	2.48 [Van]	1.66 [Car]	2.22	2.23	0.009
	# leisure businesses within 800 meters	3.01 [Pickup]	2.40	2.55	2.14 [Car]	0.016
	# eat-out businesses within 800 meters	2.97 [Van, Pickup]	1.91 [Car]	2.67	2.34 [Car]	<0.001
	Minimum distance to post office (km)	2.73 [Van, Pickup]	3.26 [Car]	2.88	3.13 [Car]	0.002
	Minimum distance to bank (km)	0.93 [Pickup]	1.00	0.93	1.06 [Car]	0.005
	Minimum distance to fast food (km)	1.03 [Van]	1.21 [Car]	1.09	1.10	0.018
	Minimum distance to pizza (km)	0.82 [Pickup]	0.89	0.85	0.92 [Car]	0.037
	Minimum distance to ice cream (km)	1.35 [Van]	1.63 [All types]	1.29 [Van]	1.31 [Van]	0.012
	Minimum distance to pharmacy (km)	0.97 [Van] [b]	1.12 [Car] [b]	0.99	1.07	0.017
	Minimum distance to bakery (km)	0.91 [SUV] [b]	1.04	1.02 [Car] [b]	1.01	0.007
Job Location	Commute distance (miles)	9.23 [SUV, Pickup [b]]	10.23	13.12 [Car]	13.22 [Car] [b]	0.007
Perceived Neighborhood Characteristics	Accessibility	0.516 [Pickup] [b]	0.338	0.461	0.354 [Car] [b]	0.030
	Outdoor spaciousness	0.029 [SUV, Pickup]	0.249	0.244 [Car]	0.290 [Car]	<0.001
Neighborhood Preferences	Outdoor spaciousness	-0.182 [All types]	0.328 [Car]	0.187 [Car]	0.238 [Car]	<0.001
Travel Attitudes	Pro-Walk/Bike	-0.034 [SUV]	-0.103	0.175 [Car]	0.089	0.019
	Pro-Transit	0.008 [Pickup]	-0.108	-0.027	-0.280 [Car]	0.002

	Safety of car	-0.042 [SUV, Pickup]	-0.030	0.182 [Car]	0.173 [Car]	0.003
Socio-demographics	Household income (k$)	67.5 [SUV]	74.5	84.5 [Car, Pickup]	69.2 [SUV]	<0.001
	Household size	2.05 [Van, SUV}	3.38 [All types]	2.48 [Car, Van]	2.24 [Van]	<0.001
	Education	4.23 [Pickup]	4.25 [Pickup]	4.36 [Pickup]	3.75 [All types]	<0.001

a. The vehicle types in brackets indicate categories whose means are significantly different from the mean of this category, at the 0.05 level if not otherwise indicated.
b. Significant at the 0.1 level.

Table 6. Nested Logit Model for Vehicle Type Choice (base alternative: passenger car)

Variables	Coefficients		
	Minivan	SUV	Pickup
Constant	-1.383 [0.000]	-2.884 [0.000]	-0.664 [0.081]
Sociodemographics			
Home owner	0.202 [0.077]		
Number of children (<18)	0.296 [0.000]	0.296 [0.000]	
Age	0.009 [0.016]		
Household income (k$)		0.012 [0.000]	
Female			-1.313 [0.000]
Education			-0.303 [0.000]
Number of vehicles			0.233 [0.038]
Neighborhood preferences			
Accessibility	-0.106 [0.013]		-0.106 [0.013]
Outdoor spaciousness	0.176 [0.001]	0.176 [0.001]	0.176 [0.001]
Travel attitudes			
Pro-bike/walk		0.287 [0.000]	0.287 [0.000]
Pro-transit			-0.423 [0.001]
Safety of car		0.331 [0.000]	
Neighborhood characteristics			
Outdoor spaciousness			0.199 [0.060]
Commute distance (miles)		0.008 [0.018]	
IV parameter		0.299 [0.000]	
Number of observations		1387	
Log-likelihood at 0: LL(0)		-2238.4	
Log-likelihood at constants: LL(C)		-1331.5	
Log-likelihood at convergence: LL		-1198.3	
Model improvement χ^2 = -2[LL-LL(C)]		266.4	
ρ^2 = 1-LL/LL(0)		0.472	
Adjusted ρ^2 = 1-(LL-18)/LL(0)		0.457	

The number in brackets indicates the p-value for that coefficient.

Figure 1. Potential Relationships between Neighborhood Design and Vehicle Type Choice

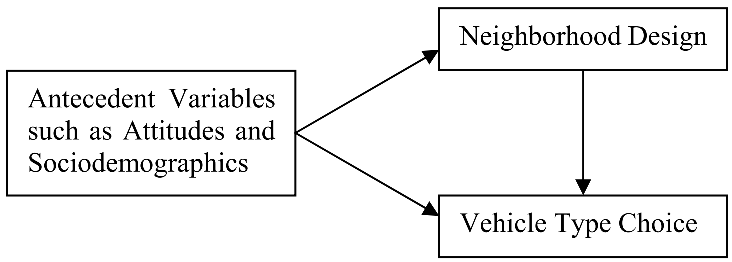

Figure 2. Nested Logit Model Structures Tested