MIXED LAND-USES AND COMMUTING: EVIDENCE FROM THE AMERICAN HOUSING SURVEY

ROBERT CERVERO
Department of City and Regional Planning, 228 Wurster Hall, University of California, Berkeley, Berkeley, CA 94720, U.S.A.

(Received 18 January 1995; in revised form 1 October 1995)

Abstract—Past research suggests that mixed land-uses encourage non-auto commuting; however, the evidence remains sketchy. This paper explores this question by investigating how the presence of retail activities in neighborhoods influences the commuting choices of residents using data from the 1985 American Housing Survey. Having grocery stores and other consumer services within 300 feet of one's residence is found to encourage commuting by mass transit, walking and bicycling, controlling for such factors as residential densities and vehicle ownership levels. When retail shops are beyond 300 feet yet within 1 mile of residences, however, they tend to encourage auto-commuting, ostensibly because of the ability to efficiently link work and shop trips by car. The presence of nearby commercial land-uses is also associated with relatively low vehicle ownership rates and short commuting distances among residents of a mixed-use neighborhood. Overall, residential densities exerted a stronger influence on commuting mode choices than levels of land-use mixture, except for walking and bicycle commutes. For non-motorized commuting, the presence or absence of neighborhood shops is a better predictor of mode choice than residential densities. Copyright © 1996 Elsevier Science Ltd

1. INTRODUCTION

Two features of the built environment are commonly thought to exert a significant influence on travel behavior: densities and levels of land-use mixture. A considerable body of research has established that urban densities have a strong influence on mode choice (Pushkarev & Zupan, 1977, 1980; Pucher, 1988; Cervero, 1994; Dunphy & Fisher, 1994), vehicle miles of travel per household (Holtzclaw, 1990, 1994), and per capita energy consumption (Newman & Kenworthy, 1989). Far less is known about the effects of mixed land-use patterns on travel demand. This paper investigates how mixed land-uses influence the commuting choices of residents from large metropolitan areas using data from the 1985 American Housing Survey. The analysis examines the effects of mixed-use levels as well as other features of the built environment like residential densities on three measures of transportation demand: commuting mode choice, commuting distance and household vehicle ownership levels.

The effects of land-use environments on mode choice are modeled using binomial logit analysis. This approach frames mode choice in terms of utility maximizing behavior. The individual commuter, as opposed to a census tract or some other statistical aggregation, is the unit of analysis. Three alternative modes of commuting are investigated: automobile (drive-alone and shared-ride), mass transit and walking/bicycling. For the analyses of commuting distance and household vehicle ownership levels, multiple regression models are estimated. Here, households are the units of analysis. The paper concludes with a summary of the key research findings and a discussion of their public policy implications.

2. PRIOR RESEARCH

Mixed land-uses are thought to yield a number of transportation benefits, especially in suburban areas (Cervero, 1988). One, to the degree that offices, shops, restaurants, banks, and other activities are intermingled amongst one another, people are less likely to drive
Robert Cervero

and more likely to walk to destinations. This should be reflected in lower vehicular trip
generation rates and higher non-motorized (e.g. walking, bicycling) modal splits in mixed-use
settings. For suburban office workers, having restaurants, shops, and other consumer services
on-site or nearby can induce ride-sharing since many no longer need to have a car available
for mid-day activities. Another benefit of mixed-use areas is that trips tend to be spread more
evenly throughout the day and week. Whereas many trips to and from office parks are during
morning and evening commute hours, if some building floorspace is instead used for
retail shops and restaurants, trips to these establishments will be generally during non-peak
periods, when road capacity is more readily available. Last, mixed-use projects create
opportunities for shared-parking arrangements. The same parking used by office workers
from 8 a.m. to 5 p.m. on Mondays through Fridays can serve restaurant and theatre-goers
during the evening and on weekends (Barton-Aschman Associates, 1983).

Empirical evidence on the transportation benefits of mixed-use environments is only
beginning to accumulate and is not totally consistent. In a comprehensive study of mixed-use
sites in Colorado, the Colorado/Wyoming Section Technical Committee (1987) of the Institute
of Transportation Engineers (ITE) found that average trip rates for individual shops in
retail plazas and other mixed commercial settings were around 2.5% below the mean rates
downward by this amount to reflect the higher likelihood of linked walk trips, instead of
separate vehicle trips, between establishments in mixed-use settings. A more recent study
found trip rates to be far lower for traditional neighborhoods with moderate residential
densities, grided street patterns, and local shops and services. Using trip data compiled for
two traditional neighborhoods in Portsmouth, New Hampshire, the White Mountain Survey
Company (1991) measured trip rates generated by these neighborhoods that were about
50% lower than those predicted by the ITE Trip Generation manual.

Several studies on employee commuting to suburban activities centers have measured
relatively low trip rates and high non-auto modal splits. Among workers at 57 large U.S. office
developments, Cervero (1988) found that every 10% increase in floorspace devoted to retail-
commercial uses was associated with a 3% increase in the share of transit and ride-sharing
commutes. A follow-up study of commuting to six large suburban activity centers, including
Perimeter Center north of Atlanta and Tyson's Corner in suburban northern Virginia,
found the existence of a retail component within a suburban office building cut vehicle-trip
rates per employee by about 8% (Cervero, 1991). Buildings with mixed uses also averaged
3% more commutes by transit than buildings containing exclusively offices.

More recent work has examined the implications of retail and other mixed uses in predomi-
nantly residential areas on non-work travel. In a comparison of shopping trips among
residents from four neighborhoods in the San Francisco Bay Area, Handy (1992) found that
those living in two traditional, mixed-use neighborhoods made two to four more walk/bicycle
trips per week to neighborhood retail stores than did those living in nearby areas that were
served mainly by automobile-oriented, strip retail establishments. Residents of mixed-use
neighborhoods, however, averaged similar rates of auto travel to regional shopping malls,
suggesting that internal walk trips might not have replaced external auto trips but rather have
been supplemental. In a recent comparison of work and non-work travel among residents
of six communities in Palm Beach County, Florida, Ewing et al. (1994) found that the
presence of shopping, recreation, and school facilities within communities can significantly
lower vehicle hours traveled (VHT) per capita. A low-density planned suburban community,
Wellington, whose residents commuted the farthest and drove the most also averaged the
shortest shopping and recreation trips because various retail shops and services were available
within the community. Another recent study addressed the influence of mixed uses on both
work and shop trips in the Seattle area. Frank and Pivo (1994) found that mixed-use
neighborhoods were most strongly correlated with walk trips to work, but rather surprisingly
they had no influence on mode choice for shop trips.

In sum, empirical evidence suggests that mixed uses reduce vehicle trip rates and auto modal
splits, however, to widely varying degrees. Whether mixed uses exert their greatest influence
on shopping and other non-work travel versus work trips is also unclear. Research by
Handy (1992) and Ewing et al. (1994) suggests that shopping trips might be most strongly influenced; however, work by Cervero (1988, 1991) and Frank and Pivo (1994) found the presence of local retail activities to significantly induce non-auto commute trips, both by workers and residents. Frank and Pivo's work actually suggests that having stores between one's residence and job site might have a stronger influence on commuting than on whether one will walk to the shops as a substitute for auto trips to shopping malls. It is to the question of how mixed uses in residential areas influence commuting by residents of those neighborhoods that we now turn.

3. HYPOTHESES AND THEORETICAL CONTEXT

The following five hypotheses are tested in this paper:

(1) Mixed-use neighborhoods induce higher shares of non-auto commuting among residents.
(2) Mixed-use neighborhoods exert their strongest influence on non-motorized commuting, specifically walk and bike travel to work.
(3) Mixed-uses only have a positive influence on transit-riding, walking, and bicycling to work if they are close by, i.e. within several blocks of a residence.
(4) Non-residential uses, such as grocery and drug stores that lie between several blocks and a mile or so of a residence, induce auto-commuting and trip-chaining.
(5) Mixed-use neighborhoods are associated with shorter distance commutes and lower vehicle ownership rates.

These research questions build upon research conducted to date on the influences of mixed uses on travel. They extend past research by focusing on how the proximity of mixed use activities, such as grocery stores, influences commuting choices. If stores are close by, they are thought to induce more walking and transit commuting, in part because the shops can be easily linked with foot travel, either to work sites or to transit stops. If they are more than several city blocks away, but within a mile of one's residence, retail shops are thought to induce auto-commuting by allowing efficient trip-chaining. In addition to studying influences on commuting modes, this research explores possible structural influences of mixed uses — specifically, on commute distances and vehicle ownership rates.

The theoretical foundation for carrying out this analysis and testing these hypotheses is rooted in the principle that travel demand is largely derived. For the most part, trips are manifestations of deeper social and economic desires that drive travel demand — namely, the need to earn a living at a workplace, to obtain medical services, or to shop at a grocery store. Accordingly, a tradition of travel demand analysis has always been to focus on characteristics of places, trip-makers, and travel modes in calibrating predictive models. Among the "place" characteristics of trips, large and dense neighborhoods, work sites, and activity centers are expected to generate relatively high volumes of trips, more often by mass transit and alternative modes, all else being equal. How levels of land-use mixtures influence travel demand is less understood. While little empirical research so far has been conducted on this question, mixed land-uses probably exert a fairly weak influence on trip generation rates. At the margin, the close proximity of retail stores and residences might allow some walk trips to substitute for motorized travel, or might result in more efficient travel, such as through increased trip chaining. The more dominant effect of mixed land-uses, however, is thought to be on modal choice. Having retail outlets between residences and transit lines, for instance, might encourage some to commute by transit if it is convenient to shop en route from transit stops to their homes in the evening. Alternatively, at the workplace, the commingling of restaurants, retail outlets, and health clubs with offices should, in principle, encourage ride-sharing — suburban workers, in particular, are less inclined to solo-commute if there are personal services that can be reached by foot during mid-day (Cervero, 1988). For these reasons, the focus of this research is on examining the associations between mixed land-uses and commuting modal choices in U.S. metropolitan areas.
4. AMERICAN HOUSING SURVEY

The American Housing Survey (AHS) is the only national survey which compiles data on commuting, neighborhood land-use composition, and household characteristics for individual housing units. Its uniqueness lies with providing data on the presence of non-residential land uses, such as retail shops and public buildings, in the vicinity of surveyed housing units. Land use mixture, however, is gauged as a simple binary (0–1) variable, i.e. either non-residential uses exist or not within some defined geographic area. Additionally, the AHS identifies surrounding residential densities using ordinal classifications; specifically, nearby housing is characterized as being either single-family detached, low-rise multi-family, mid-rise multi-family, or high-rise multi-family. In sum, the AHS provides the only national data base that records data on both commuting and neighborhood land-use characteristics for randomly sampled households in urbanized parts of the country.

The AHS is conducted every 4 yr on housing units in 44 metropolitan statistical areas (MSAs) with populations above 1 million.* Although AHSs of metropolitan housing units were carried out in 1985, 1989 and 1993, the last two surveys did not compile much information on neighborhood land-use characteristics. For budgetary reasons, questions regarding the presence of non-residential activities in the neighborhood that were compiled in 1985 were omitted from the 1989 and 1993 surveys. Moreover, the 1985 survey compiled data for 42,200 housing units across 11 MSAs; the 1989 and 1993 surveys were smaller — each with around 35,000 surveyed units.

The 11 MSAs surveyed in the 1985 AHS are (with the number of surveyed housing units shown in parentheses):

- Boston–Lawrence–Lowell, MA–NH (4017)
- Dallas, TX (3276)
- Detroit, MI (6516)
- Los Angeles–Long Beach, CA (6572)
- Fort Worth–Arlington, TX (3218)
- Minneapolis–St. Paul, MN (3726)
- Philadelphia, PA–NJ (6774)
- Phoenix, AZ (3645)
- San Francisco–Oakland, CA (6656)
- Tampa–St. Petersburg FL (3755)

In the analyses that follow, all surveyed households within these 11 MSAs were initially included. Since many of the surveyed households did not record the requested information on neighborhood land-use characteristics, the number of surveyed units with complete land-use data available for modeling was reduced by over two-thirds. For most of the below analyses, between 9800 and 15,200 housing unit records were sufficiently complete to support modeling.

5. RESEARCH METHODS AND VARIABLES

For examining how mixed uses and other features of the land-use environment shape mode choice, binomial discrete choice models of the following form were estimated:

\[
\text{prob}(Y_i = k) = \frac{1}{1 + \exp(-U_i)} Y_i = k,
\]

where: \( U_i = b_0 + b_1X_{i1} + b_2X_{i2} + \ldots + b_qX_{iq}, \)

\( Y_i = \) commuting mode \( k \) for employed resident \( i; \)

\( X = \) independent utility variable, \( 1...q. \)

Equation (1) expresses the probability of commuting by a particular mode as a function of a vector of land-use and other variables that collectively define utility, \( U_i. \) In this analysis,

*There are four sets of MSAs, 11 in each set. Each set is surveyed once every 4 yr on a rotating basis. Some of the MSAs surveyed actually consist of consolidated metropolitan statistical areas (CMSAs).
utility variables are distinguished as either land-use (e.g. density, non-residential uses) or control variables. Additionally, k represents commuting mode expressed in binary terms (e.g. automobile versus other). Parameters are estimated using maximum likelihood techniques.

The following specific variables were used in estimating utility expressions for the three modes:

**Land-use variables:**
- Single-family detached housing within 300 feet of unit (0 = no, 1 = yes)
- Low-rise multi-family buildings or single-family attached units within 300 feet of unit (0 = no, 1 = yes)
- Mid-rise multi-family buildings within 300 feet of unit (0 = no, 1 = yes)
- High-rise multi-family buildings within 300 feet of unit (0 = no, 1 = yes)
- Commercial or other non-residential buildings within 300 feet of unit (0 = no, 1 = yes)*
- Grocery or drug store between 300 feet and 1 mile of unit (0 = no, 1 = yes)*

**Control variables:**
- Residence in the central city of the MSA (0 = no, 1 = yes)
- No. of private automobiles available in household
- Annual household income
- Four-lane highway, railroad, or airport within 300 feet of unit (0 = no, 1 = yes)
- Public transportation adequate in neighborhood (0 = no, 1 = yes)
- Distance from home to work, one way in miles.

The first four land-use variables listed above represent overall neighborhood density within 300 feet (the length of a football field) of a surveyed housing unit. In general, a neighborhood comprising detached single-family homes will average nine or fewer dwelling units per acre. For metropolitan areas which have a population over 1 million (such as surveyed in the 1985 AHS), single-family residential densities tend to be on the higher side, in the 6–9 d.u. per acre range (though quarter-acre lots certainly can be found in planned developments in the suburbs of large U.S. metropolitan areas). Neighborhoods with low-rise (one- to two-storey) multi-family housing and attached single-family homes (e.g. row houses, duplexes, four-plexes) generally correspond to residential densities in the 10–24 d.u. per acre range. Neighborhoods with mid-rise housing, representing three- to six-storey structures with lobbies and elevators, average densities in the 25–60 d.u. per acre range, and neighborhoods with high-rise apartments and condominiums typically have densities above 60 d.u. per acre. In sum, four ordinal levels of neighborhood densities are captured by the AHS.

The remaining two land-use variables used from the AHS identify the levels of mixture. One variable signifies the presence of retail shops and other non-residential activities within 300 feet of a surveyed unit — generally a one- or two-block distance. The other variable identifies whether, specifically, a grocery or drug store lies between 300 feet and 1 mile of a surveyed residence. Thus, the first mixed use variable identifies whether there are non-

*The AHS specifically asks two questions about non-residential activities in respondents’ neighborhoods: (1) whether there are “commercial/institutional/industrial buildings within 300 feet” of their dwelling unit (question reference number 297); and (2) whether “commercial, industrial, and non-residential activities are present” (question reference number 331). According to the codebook for the AHS, a neighborhood “is defined as 300 feet in any direction from the front of the building” (Hadden & Leger, 1990, p. 70). Thus, while the words “within 300 feet” were not specifically stated for the second question, it is assumed that in responding to the presence of such activities in their neighborhood, respondents weighed whether such land-uses were in the immediate vicinity — more or less within 300 feet. In this study, an affirmative response to either the first question (number 297) or the second question (number 331) was treated as constituting what is called “commercial, institutional, industrial, or other non-residential land-uses” in this study.

1In the series of questions on neighborhood characteristics, the AHS asks whether there is a “grocery or drug store within 1 mile” of the respondents’ dwelling unit (question reference number 359). In order to distinguish whether grocery or drug stores were close by (within 300 feet) or relatively far away, a variable was created which assigned a value of 1 to cases where a grocery or drug store was within 1 mile of a respondents’ residence but there were no commercial or other non-residential activities within 300 feet of their residence.

2This variable serves as a proxy for transit service levels in the neighborhood. It is a subjective measure based on a simple 0–1 binary response; however, it represents the only variable in the data set that reflects transit service levels.
residential activities in the immediate vicinity, whereas the second variable specifies whether there are food and drug stores in the area, but beyond a convenient walking distance.

The 1985 AHS compiles data on the "principal means of transportation to work" for up to eight members of each surveyed housing unit. In this study, data were extracted for up to two wage-earners in each household with the highest annual salaries. Over 98% of households surveyed in the 1985 AHS had one or two wage-earners.

It is important to note that the binomial models presented in this article were designed for testing the specific research hypotheses posed, as opposed to estimating best-fitting models for forecasting travel demand, such as part of an urban transportation planning systems (UTPS) analysis. That is, the estimated models do not express utility based on a complete array of characteristics of different choice sets, such as relative travel times and price characteristics of competing modes. The limited numbers of explanatory variables used in the analysis are largely a concession to the data limitations of the AHS. Nor are multinomial models estimated, as might be justified if travel demand forecasting models were calibrated as part of a long-range regional planning effort. Instead, binomial logit models are opted for in order to test how various land-use characteristics of residential neighborhoods influence the decision to commute by a specific mode or not.* As such, the analysis is meant to shed light on the importance of mixed land-uses vis-à-vis density, income, and other household-related factors in predicting the likelihood of residents choosing a particular mode of commuting.

6. DESCRIPTIVE STATISTICS

Among the 42,200 households surveyed in the 11 U.S. MSAs, the private automobile was by far the dominant means of getting to work in 1985. The commute modal splits (excluding those who worked at home) were: automobile or truck (drive alone or share ride) — 85.5%; public transit — 9.4%; walking or bicycling — 4.2%; and other — 0.9%.

Table 1 presents summary statistics for both the land-use variables and other control variables used as predictors in the models that follow. Around two-thirds of the households surveyed in the 1985 AHS were surrounded by single-family detached units; only one out of ten was located within 300 feet of mid-rise apartments, and only one out of 20 was within

Table 1. Descriptive statistics summaries for predictor variables, all metropolitan statistical areas combined

| Percent of surveyed households with land-uses of the following type within 300 feet |
|---------------------------------|----------------|
| Single-family detached          | 66.4%          |
| Single-family attached/lower-rise multi-family buildings | 41.6%          |
| Mid-rise multi-family buildings  | 10.0%          |
| High-rise multi-family buildings | 5.1%           |
| Commercial or other non-residential buildings | 21.3%          |
| Grocery or drug store           | 55.0%          |

<table>
<thead>
<tr>
<th>Percent of surveyed households</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residing in central city of the MSA</td>
</tr>
<tr>
<td>Where four-lane highway, railroad, or airport lies within 300 feet of unit</td>
</tr>
<tr>
<td>With adequate public transportation services in the neighborhood</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mean (standard deviation) for remaining control variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of private automobiles available in household</td>
</tr>
<tr>
<td>No. of people per household</td>
</tr>
<tr>
<td>Annual household income ($)</td>
</tr>
<tr>
<td>Distance from home-to-work, one way miles</td>
</tr>
<tr>
<td>Travel time from home-to-work, minutes</td>
</tr>
</tbody>
</table>

*As with standard mode choice models, the logisitic functional form is appropriate for this analysis because of its inherent advantages for predicting discrete binary choices, whether utility is expressed in terms of land-use characteristics (as in this analysis) or generalized costs (as in most UTPS mode choice models). Besides constraining probability estimates to fall between 0 and 1, the logistic curve has the desirable qualities that probability estimates are non-linear functions of utility and estimates for discrete observations normally fall toward 0 or 1 because of the asymptotic form of the curve (Aldrich & Nelson, 1984).
a block or so of high-rise residential buildings. While just 21% had non-residential uses nearby, over half of the surveyed households had a grocery or drug store between 300 feet and 1 mile from their residence.

Among the non-land-use variables used in this study, Table 1 shows that slightly over half of the surveyed households were located in the central city of the MSA and nearly half believed their neighborhood received adequate public transportation services. The typical employed-resident surveyed commuted 11 miles one-way to work, reaching his or her job site in around 23 min.

Because most of the variables available from the AHS were binary, it was possible to run simple cross-tabulations in exploring relationships between land-use variables and modal choices. The relationships found were consistent with and more fully amplified by the binomial logit models that follow. For this reason, these exploratory cross-tabulations are not presented here, although plots generated from the logit model results that are presented later in this paper reflect many of the same relationships revealed by cross-tabulations.

7. PRIVATE AUTOMOBILE COMMUTING MODEL

The binomial logit model estimated for predicting the probability of commuting by private automobile, either alone or with a passenger, is shown in Table 2. Controlling for other factors, the model reveals that the land-use environment of the 11 MSAs exerted a statistically significant influence on automobile commuting. The probability of auto-commuting increases if someone lives in a neighborhood with single-family detached or attached units or low-rise apartments, and declines in a neighborhood with mid-rise and high-rise buildings.

Hypotheses on how mixed uses influence commuting choices were confirmed. Having retail or other non-residential uses within 300 feet of one's residence lowers the probability

<table>
<thead>
<tr>
<th>Land-use variables:</th>
<th>Coefficient</th>
<th>Standard error</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-family detached within 300 feet of unit</td>
<td>0.3718</td>
<td>0.00015</td>
<td>0.0001</td>
</tr>
<tr>
<td>Single-family attached/low-rise multi-family buildings within 300 feet of unit</td>
<td>0.1065</td>
<td>0.00014</td>
<td>0.0001</td>
</tr>
<tr>
<td>Mid-rise multi-family buildings within 300 feet of unit</td>
<td>-0.7420</td>
<td>0.00019</td>
<td>0.0001</td>
</tr>
<tr>
<td>High-rise multi-family buildings within 300 feet of unit</td>
<td>-0.9017</td>
<td>0.00026</td>
<td>0.0001</td>
</tr>
<tr>
<td>Commercial and other non-residential buildings within 300 feet of unit</td>
<td>-0.1512</td>
<td>0.00015</td>
<td>0.0001</td>
</tr>
<tr>
<td>Grocery or drug store between 300 feet and 1 mile of unit</td>
<td>0.0249</td>
<td>0.00026</td>
<td>0.0001</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Control variables:</th>
<th>Coefficient</th>
<th>Standard error</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residence within central city of MSA</td>
<td>-0.2173</td>
<td>0.00014</td>
<td>0.0001</td>
</tr>
<tr>
<td>No. of private automobiles in household</td>
<td>1.2028</td>
<td>0.00010</td>
<td>0.0001</td>
</tr>
<tr>
<td>Public transit services adequate</td>
<td>-0.8994</td>
<td>0.00015</td>
<td>0.0001</td>
</tr>
<tr>
<td>Distance from home to work, one way in miles</td>
<td>0.0356</td>
<td>0.00001</td>
<td>0.0001</td>
</tr>
<tr>
<td>Constant</td>
<td>0.5254</td>
<td>0.00038</td>
<td>0.0001</td>
</tr>
</tbody>
</table>

Summary statistics:

\[ \rho^2 = 0.249 \]

Model Chi-square = 501,233,920; probability = 0.0001
Percent of cases correctly predicted (concordant pairs) = 80.4
No. of cases = 9823
of auto-commuting, whereas having a grocery or drug store beyond 300 feet but within a 1 mile radius increases the odds, controlling for the influence of other factors, including density. This probably reflects the tendency for mixed uses in one's immediate neighborhood to encourage commuting by foot or transit, assuming home-to-work distances are not too long. Having stores between a transit stop and one's residence, for instance, allows transit riders to conveniently shop while en route home in the evening, thus linking work and shop trips in a single tour.\(^*\) Having grocery and drug stores between 300 feet and a 1 mile radius, on the other hand, encourages car commuting because, presumably (for most survey respondents), these destinations can be more easily reached by automobile than by foot, bicycle, or as part of a transit trip. In particular, having stores within the vicinity, though not within a few blocks, of one's residence probably encourages automobile commuting by allowing one to easily shop on the way home from work. This is consistent with the findings of Ewing \textit{et al.} (1994) that suburban communities in Palm Beach County, Florida with self-contained shopping and recreation facilities averaged high levels of auto-commuting, but also high levels of trip-chaining. The residents of the master-planned suburban community, Wellington, commuted the farthest and drove most of all residents in the county, but also averaged the shortest shopping and recreational trips because many retail shops and services were available within the community.

The coefficients on all control variables in Table 2 are consistent with expectations.\(^+\) The odds of automobile commuting increase with home-to-work distance and levels of vehicle ownership. The likelihood is lower, however, for those residing in the central city of an MSA and where public transit services are viewed as adequate (a proxy for transit service quality).

To provide additional insights into how residential density and land-use mixture influence automobile commuting, Fig. 1 was prepared. The figure plots the probability of auto-commuting (using the estimated logit model) for four different land-use scenarios, controlling for other factors. Two levels of neighborhood density are shown: (1) low-density

![Fig. 1. Probability of commuting by automobile for four land-use scenarios.](image_url)

\(^*\)Following the convention of Ewing \textit{et al.} (1994), a tour is defined as a complete circuit between one's residence and some other destination or destinations. As used in this example, the person is making a work-trip tour since the primary destination is the workplace. Other stops, such as to retail shops, are secondary to the purpose of going to work.

\(^+\)The constant term in this and other models presented in this paper has no theoretical significance. Its practical significance is that it scales the utility expression of the logistics function to produce probability estimates that provide the best fit of empirical data.
Mixed land-uses and commuting

(single-family detached, and single family attached/low-rise multi-family units) and (2) mid-rise and high-rise multi-family buildings. Two land-use composition scenarios are also presented: (1) mixed-use and (2) single-use, where the former consists of residences with commercial and other non-residential buildings within 300 feet, and the latter does not. In these scenarios, it is assumed that there are no grocery- or drug stores within 300 feet to 1 mile from the residences.* These scenarios also assume that people reside in a central city, have adequate public transit services, and commute 10 miles each way. The number of private automobiles per household functions as a co-variante in Fig. 1.

Figure 1 shows that neighborhood density exerts a much stronger influence on auto-commuting than the level of land-use mixture. For workers with a single automobile in their household, the odds of auto-commuting are 0.78-0.80 if they live in a low-density neighborhood versus 0.29-0.34 if they live in an area with mid-rise and high-rise apartments. Having commercial and other activities within 300 feet lowers the probability of auto-commuting by only 2-5%. The presence of mixed uses lowers auto-commuting slightly more in high-density than low-density neighborhoods. Overall, the interactive effects of density and mixed-uses on auto-commuting appear fairly weak. Lastly, automobile ownership rates are shown to have a very strong influence on auto-commuting. With four vehicles in a household, the probability of automobile commuting is well over 90%, regardless of neighborhood density or land-use composition.

8. TRANSIT COMMUTING MODEL

Findings on how the land-use environment influences transit commuting were consistent with those of the auto-commuting model. Table 3 reveals that the odds of transit commuting decline if one lives in a neighborhood with single-family detached units and rises in settings with attached housing, be they low-rise, mid-rise, or high-rise, all other things being equal. Living in an area with mid-rise (three- to six-storey) apartments and condominiums was more conducive to transit commuting than any of the land-use variables.

Consistent with the previous findings, having retail stores and other non-residential activities in the neighborhood induced transit commuting. Based on the size of the model coefficient, however, this influence was fairly weak. Also consistent with the earlier findings, the presence of a grocery- or drug store between 300 feet and 1 mile from one's residence lowered the odds of transit commuting, ostensibly because an automobile is better suited for linking work trips to grocery and consumer shopping than a bus or train.

Table 3 also reveals that control variables exerted a stronger influence on transit commuting than the land-use variables. Specifically, the presence of adequate transit services and living in a central city increased transit commuting more strongly than variables measuring the presence of high-rise buildings or mixed land-uses. Increasing vehicle ownership levels had a particularly strong effect on reducing transit commuting.

The effects of three variables — density, land-use composition, and vehicle ownership — on transit commuting are summarized in Fig. 2. Four land-use scenarios are presented, holding other factors constant. Specifically, the scenarios are drawn for those living in a central city where public transit services are adequate and there are no grocery or drug stores within 300 feet to 1 mile radius of their residences.*

*If grocery or drug stores were assumed to be within 300 feet and 1 mile of a residence, the probabilities of auto-commuting would have increased for all four scenarios. The presence of commercial activities nearby but no grocery or drug stores within a 300 foot to one-mile radius is presumed to represent a setting where someone has shops nearby (e.g. restaurants, bakery, cleaners) that do not include a grocery or drug store. Thus, the primary distinction drawn in the scenario is whether non-residential uses are nearby, e.g. within one or two city blocks.

The average one-way commute for the 11 MSAs was around 11 miles.

1Automobile ownership was strongly correlated with household income \( r = 0.478 \). Including both variables in an equation generally posed significant multicollinearity problems. In most cases, automobile ownership alone was used as a predictor of mode choice. Automobile ownership thus functions as both a supply-side measure of automobile and a demand-side proxy for household income.

2If the scenarios assumed that grocery or drug stores were within 300 feet to 1 mile from a person's residences, the probabilities would have fallen slightly (i.e. the curves would have been slightly lower).
Table 3. Logit model for predicting probability of commuting by public transit, all metropolitan statistical areas combined

<table>
<thead>
<tr>
<th>Land-use variables:</th>
<th>Coefficient</th>
<th>Standard error</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-family detached within 300 feet of unit</td>
<td>-0.3163</td>
<td>0.00011</td>
<td>0.0001</td>
</tr>
<tr>
<td>Single-family attached/low-rise multi-family buildings within 300 feet of unit</td>
<td>0.2156</td>
<td>0.00015</td>
<td>0.0001</td>
</tr>
<tr>
<td>Mid-rise multi-family buildings within 300 feet of unit</td>
<td>0.7351</td>
<td>0.00018</td>
<td>0.0001</td>
</tr>
<tr>
<td>High-rise multi-family buildings within 300 feet of unit</td>
<td>0.0922</td>
<td>0.00107</td>
<td>0.0001</td>
</tr>
<tr>
<td>Commercial and other non-residential buildings within 300 feet of unit</td>
<td>0.1730</td>
<td>0.00042</td>
<td>0.0001</td>
</tr>
<tr>
<td>Grocery or drug store between 300 feet and 1 mile of unit</td>
<td>-0.0919</td>
<td>0.00040</td>
<td>0.0001</td>
</tr>
<tr>
<td>Control variables:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Residence within central city of MSA</td>
<td>0.6694</td>
<td>0.00018</td>
<td>0.0001</td>
</tr>
<tr>
<td>No. of private automobiles in household</td>
<td>-0.6509</td>
<td>0.00018</td>
<td>0.0001</td>
</tr>
<tr>
<td>Public transit services adequate</td>
<td>-0.5811</td>
<td>0.00176</td>
<td>0.0001</td>
</tr>
<tr>
<td>Constant</td>
<td>-2.1531</td>
<td>0.00078</td>
<td>0.0001</td>
</tr>
</tbody>
</table>

Summary statistics:

- $p^2 = 0.87$
- Model Chi-square = 250,791.441; probability = 0.0001
- Percent of cases correctly predicted (concordant pairs) = 77.4
- No. of cases = 15,258

Again, we see that density exerts a stronger influence on commuting than the presence of nearby mixed uses. Under the scenario where someone lives in a household with one car, the odds of transit commuting are 0.27–0.29 if they live in a neighborhood with mid- and high-rise apartments and condominiums and 0.8–0.9 if their neighborhood consists of single-family detached homes. As shown before, the existence of mixed uses has a slightly stronger effect on commuting in higher than lower density neighborhoods. Where workers live...
in an area with single-family detached units and have two or more cars available, the
odds of transit commuting are indistinguishable, regardless of whether non-residential
uses are nearby. Also regardless of the land-use environment, the odds of transit commuting
fall below 6% if someone lives in a household with four automobiles.

9. WALKING/BICYCLING COMMUTE MODEL

Of all mode choice models estimated, the best-fitting model predicted walking and bicycling
commuting. Table 4 shows that, consistent with the other models, densities significantly
influence whether someone walks or cycles to work. Living in a neighborhood with single-fam-
ily homes and low-rise buildings lowers the probability of non-motorized commuting, whereas
a higher-density residential setting, especially one with mid-rise structures, increases the odds.

Unlike the previous findings, however, the presence of mixed-uses has a fairly strong
and significant influence on non-motorized commuting. Specifically, having commercial and
other non-residential activities in the immediate vicinity of one’s residence induces people
to walk or bicycle to work, holding factors such as trip distance and vehicle ownership
levels constant.* The existence of a grocery or drug store beyond 300 feet but within 1 mile,

Table 4. Logit model for predicting probability of commuting by walking or bicycling, all metropolitan statistical
areas combined

<table>
<thead>
<tr>
<th>Land-use variables:</th>
<th>Coefficient</th>
<th>Standard error</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-family detached within 300 feet of unit</td>
<td>-0.2203</td>
<td>0.0029</td>
<td>0.0001</td>
</tr>
<tr>
<td>Single-family attached/low-rise multi-family buildings within 300 feet of unit</td>
<td>-0.0379</td>
<td>0.00027</td>
<td>0.0001</td>
</tr>
<tr>
<td>Mid-rise multi-family buildings within 300 feet of unit</td>
<td>0.2372</td>
<td>0.00035</td>
<td>0.0001</td>
</tr>
<tr>
<td>High-rise multi-family buildings within 300 feet of unit</td>
<td>0.1596</td>
<td>0.00044</td>
<td>0.0001</td>
</tr>
<tr>
<td>Commercial and other non-residential buildings within 300 feet of unit</td>
<td>0.3697</td>
<td>0.00027</td>
<td>0.0001</td>
</tr>
<tr>
<td>Grocery or drug store between 300 feet and 1 mile of unit</td>
<td>-0.4142</td>
<td>0.00019</td>
<td>0.0001</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Control variables:</th>
<th>Coefficient</th>
<th>Standard error</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residence within central city of MSA</td>
<td>0.00248</td>
<td>0.00028</td>
<td>0.0001</td>
</tr>
<tr>
<td>No. of private automobiles in household</td>
<td>-0.6990</td>
<td>0.00017</td>
<td>0.0001</td>
</tr>
<tr>
<td>Public transit service adequate</td>
<td>0.5382</td>
<td>0.00028</td>
<td>0.0001</td>
</tr>
<tr>
<td>Distance from home to work, one way in miles</td>
<td>-1.1233</td>
<td>0.00011</td>
<td>0.0001</td>
</tr>
<tr>
<td>Constant</td>
<td>0.5531</td>
<td>0.00089</td>
<td>0.0001</td>
</tr>
</tbody>
</table>

Summary statistics:
\[ \chi^2 = 0.532 \]
Model Chi-square = 481,454,880; probability = 0.0001
Percent of cases correctly predicted (concordant pairs) = 91.2
No. of cases = 9805

*The distinction between the two mixed-use variables for neighborhood activities is somewhat vague. From
the AHS codebook, one question asks whether there are "commercial/institutional/industrial buildings within
300 feet" while the other asks whether there are "commercial, industrial, non-residential activities present" in
the neighborhood (Hadden & Leger, 1990). There is likely a fair amount of overlap in these questions. The
former is a bit more specific, pin-pointing whether three types of uses are within a defined radius of one's
home. The second question encompasses seemingly any kind of non-residential activities within a less-defined
spatial context. It is believed that the former question most directly relates to the existence of shops, public
buildings (e.g. libraries, schools), and industrial structures within a block or two of respondents' residences.
The second question identifies these and other non-residential activities within the general vicinity, which likely
encompasses a larger area, say one to four blocks from respondents' residences.
however, deters walk and bicycle commuting, ostensibly because the private automobile is better suited for accessing commercial establishments outside the immediate neighborhood but reasonably close by.

Table 4 shows that both vehicle ownership levels and commute distance lower the odds of commuting by foot or bicycle. Home-to-work distances have a stronger bearing on whether people walk or bike to work than any single factor. Interestingly, having adequate transit services induces non-motorized commuting, ostensibly because people have the option of riding transit for one leg of the commute trip. For example, during the winter months when it turns dark in the early evening, some living within reasonable proximity of their workplaces might opt to walk to work in the morning and return by transit in the evening.

Two sets of scenarios were plotted for portraying factors influencing walking and bicycle commuting. Combinations of density and mixed uses were plotted against two different co-variates: automobile ownership and commute distance, both of which were strong predictors. In the first scenario, shown in Fig. 3, it is assumed the person lives 1 mile from his workplace. Low-density is defined as neighborhoods with single-family units and low-rise residential buildings, whereas high density denotes areas with mid-rises and high-rises. The scenarios shown in Fig. 3 also assume that public transit services are adequate and that there are no grocery- or drug stores within a radius of 300 feet to 1 mile from one's residence.

Figure 3 shows that non-motorized commuting rises in relatively dense, mixed-use settings. Here, we see that land-use composition exerts at least as strong of an influence on walking and bicycling as do residential densities. The probability of walking or biking to work is virtually identical for someone living in a low-density, mixed-use neighborhood as in a neighborhood of high-rise residential towers. For those living a mile from their jobs and having one car in the household, there is a 0.55 chance they will walk or bike to work if they live in dense, mixed-use neighborhoods; if the dense neighborhoods consist only of residences, however, the odds fall to 0.38. If someone lives in a low-density neighborhood, the probability of walking or biking to work is also 0.38 if there are mixed land-uses, but only 0.23 if there are only homes in the area. As vehicle ownership levels rise, the odds of non-motorized commuting fall sharply, regardless of land-use environment.

The second set of scenarios, shown in Fig. 4, plots probabilities against commute distances ranging from one-eighth of a mile to a mile-and-a-half. All other factors remain the same.

![Fig. 3. Probability of commuting by walking or bicycling for four land-use scenarios, as a function of vehicle ownership levels.](image-url)
Mixed land-uses and commuting

except that the hypothetical household examined in Fig. 4 is assumed to have two automobiles.* In general, the same relationship holds: walking and bicycling tends to be much higher in higher-density, mixed-use settings, almost regardless of distance. For someone residing a quarter of a mile from their job, there is a 0.57 likelihood they will walk or bicycle to work if they live in a dense, mixed-use area; if they live in a neighborhood populated only by single-family homes, however, the odds fall to 0.28. Again, the odds are virtually identical if the neighborhood is low-density with mixed uses versus high-density with single uses. The presence of mixed uses has the strongest influence for journeys to work of 1 mile or less. Beyond 1 mile, non-residential uses exert a weaker influence on walking and bicycling, as revealed by the tendency for the curves in Fig. 4 to converge beyond 1 mile. Even at a mile and a half commute distance, however, there is a one-quarter chance that someone living in a mid/high-rise neighborhood with surrounding stores will walk or bike to work in these 11 MSAs.

10. VEHICLE OWNERSHIP AND COMMUTE DISTANCE MODELS

In addition to mode choice, the 1985 AHS allowed the influences of different land-use environments on several other measures of transportation consumption to be measured — vehicle ownership and commuting distance. An additional control variable included in these models was annual household income. To control for family size, the number of household members was also employed. Because of the interdependence of vehicle ownership and metropolitan location (and thus commuting distance), regression models were simultaneously estimated (McFadden, 1978). (That is, vehicle ownership was thought to be a significant predictor of residential location and hence commuting distance, while commuting distance itself likely has a bearing on vehicle ownership levels.) Reduced form estimates of the endogenous variables — vehicles per household and commuting distance — were derived by creating instruments from the predetermined variables (i.e. all of the land-use variables as well as any exogenous variables extracted from the AHS data base, such as monthly housing expenses.) Two-stage least squares estimates of the simultaneous equations are shown in Tables 5 and 6.

Fig. 4. Probability of commuting by walking or bicycling for four land-use scenarios, as a function of commute distance.

*This was the modal category (most frequently occurring) of vehicle ownership levels among the 11 MSAs. If a lower vehicle ownership rate was assumed, the curves in Fig. 4 would be higher. If a higher rate was assumed, the opposite would hold.
Consistent with expectations, Table 5 shows that, controlling for factors like location within an MSA, vehicle ownership levels decline with neighborhood density and the presence of non-residential land-uses in the area. Relative to a neighborhood with single-family detached units (the suppressed category for neighborhood type), households in high-rise apartments are likely to own 0.47 fewer vehicles, all else being equal. Having mixed uses nearby has a far weaker influence on vehicle ownership than density. Still, the implication is that having consumer services within a residential community might reduce the need for owning a second or third vehicle, to the degree that some purchases can be easily made by foot travel.

Table 5 also shows that vehicle ownership levels rise with household income and size as well as with commuting distance. Living within a central city with adequate transit services lowers vehicle ownership rates, though only slightly.

The other simultaneously estimated model, shown in Table 6, reveals that commuting distances tend to be shorter for those living in dense, mixed-use neighborhoods. Those living in high-rise buildings in central cities commuted, on average, around a mile less each way than those living in single-family housing or mid-rise buildings (the suppressed categories for housing type). Having mixed uses in the immediate neighborhood was associated with one-way commutes that were around 1.6 miles shorter, all else being equal. These results could reflect the tendency for those living in denser central-city neighborhoods with higher levels of mixed land-uses to be relatively close to jobs, especially downtown jobs. They might also reflect the influences of residential sorting, wherein those placing a high value on urban amenities and who want to economize on commuting search out neighborhoods that are mixed-use in character and reasonably close to their jobs. To begin to unravel these complex relationships would require a far more robust data set than that provided by the AHS, ideally one which is longitudinal.

Table 5. Regression model for predicting vehicle ownership levels, all metropolitan statistical areas combined, simultaneous model estimate

<table>
<thead>
<tr>
<th>Land-use variables:</th>
<th>Coefficient</th>
<th>Standard error</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-family attached/low-rise multi-family buildings within 300 feet of unit</td>
<td>-0.1013</td>
<td>0.0196</td>
<td>0.0001</td>
</tr>
<tr>
<td>Mid-rise multi-family buildings within 300 feet of unit</td>
<td>-0.2734</td>
<td>0.0256</td>
<td>0.0001</td>
</tr>
<tr>
<td>High-rise multi-family buildings within 300 feet of unit</td>
<td>-0.4753</td>
<td>0.0684</td>
<td>0.0001</td>
</tr>
<tr>
<td>Commercial and other non-residential buildings within 300 feet of unit</td>
<td>-0.1248</td>
<td>0.0467</td>
<td>0.0001</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Control Variables:</th>
<th>Coefficient</th>
<th>Standard error</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residence within central city of MSA</td>
<td>-0.1134</td>
<td>0.0150</td>
<td>0.0001</td>
</tr>
<tr>
<td>No. of persons living in household</td>
<td>0.1073</td>
<td>0.0043</td>
<td>0.0001</td>
</tr>
<tr>
<td>Annual household income in $1000</td>
<td>0.0124</td>
<td>0.0003</td>
<td>0.0001</td>
</tr>
<tr>
<td>Public transit services adequate</td>
<td>-0.0417</td>
<td>0.0143</td>
<td>0.0028</td>
</tr>
<tr>
<td>Distance from home to work, one way in miles*</td>
<td>0.0132</td>
<td>0.0047</td>
<td>0.0056</td>
</tr>
<tr>
<td>Constant</td>
<td>0.7612</td>
<td>0.0043</td>
<td>0.0001</td>
</tr>
</tbody>
</table>

Summary statistics:

$R^2 = 0.211$

$F = 214.53;$ probability = 0.0001

No. of cases = 9804

*Reduced form estimate.
Table 6 shows that location had an even stronger influence on commute distances — controlling for land-use environment and other factors, those living in the central city commuted, on average, around 3 fewer miles each way than those living in the suburbs. Having adequate transit services was also associated with relatively short commutes. Good quality transit services could influence commute distances indirectly by influencing residential location. Those working downtown or in other locations well served by transit have been found to choose residential locations that allow them to transit commute. Voith (1991) found examples of such residential sorting in the greater Philadelphia area, and Cervero and Menotti (1994) found similar patterns in the San Francisco Bay Area.

11. CONCLUSION

The core hypotheses on how land-use environments, and mixed uses in particular, affect commuting behavior are supported by these research results. Neighborhood densities have a stronger influence than mixed land-uses on all commuting mode choices, except for walking and bicycling. For non-motorized commuting, the presence or absence of neighborhood shops is a better predictor of mode choice than residential densities. The likelihood of non-auto commuting increases significantly as neighborhood densities rise and where there are shops and other non-residential activities in the immediate neighborhood.

This research also shows that the relative proximity of mixed-use development matters greatly. If retail shops are within 300 feet, or several city blocks, from a dwelling unit, workers are more likely to commute by transit, foot or bicycle. Beyond this distance, however, mixed use activities appear to induce auto-commuting. This could be because of the ability to efficiently link work and shopping trips by automobile where retail activities are beyond an easy walking distance of one's home. This is consistent with the research findings of Ewing et al. (1994).

In addition, neighborhood density and mixed land-uses tended to reduce vehicle ownership rates and were associated with shorter commutes, controlling for other factors such as household income. In combination, the effects of reducing auto-commuting, commute distances,

Table 6. Regression model for predicting commute distance, all metropolitan statistical areas combined, simultaneous model estimate

<table>
<thead>
<tr>
<th>Land-use variables:</th>
<th>Coefficient</th>
<th>Standard error</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>High-rise multi-family buildings</td>
<td>-1.0228</td>
<td>0.5025</td>
<td>0.0484</td>
</tr>
<tr>
<td>within 300 feet of unit</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commercial and other non-residential</td>
<td>-1.6448</td>
<td>0.0533</td>
<td>0.0001</td>
</tr>
<tr>
<td>buildings within 300 feet of unit</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grocery or drug store between 300 feet</td>
<td>-0.8902</td>
<td>0.3954</td>
<td>0.0245</td>
</tr>
<tr>
<td>and 1 mile of unit</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Control variables:

<table>
<thead>
<tr>
<th>Residential features within central city of MSA</th>
<th>Coefficient</th>
<th>Standard error</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residence within central city of MSA</td>
<td>-3.091</td>
<td>0.1643</td>
<td>0.0001</td>
</tr>
<tr>
<td>Annual household income, in $1000</td>
<td>0.0078</td>
<td>0.0002</td>
<td>0.0001</td>
</tr>
<tr>
<td>Public transit services adequate</td>
<td>-0.3867</td>
<td>0.1976</td>
<td>0.0505</td>
</tr>
<tr>
<td>No. of private automobiles in household*</td>
<td>1.3542</td>
<td>0.2996</td>
<td>0.0001</td>
</tr>
<tr>
<td>Constant</td>
<td>8.6871</td>
<td>0.7637</td>
<td>0.0001</td>
</tr>
</tbody>
</table>

Summary statistics:

- $R^2 = 0.051$
- $F = 126.37$; probability = 0.0001
- No. of cases = 9804

*Reduced form estimate.
and vehicle ownership rates suggest that moderate-to-high density, mixed-use neighborhoods average less vehicle-miles-traveled (VMT) per capita than lower density, exclusively residential ones. This is consistent with the research findings of Holtzclaw (1990, 1994).

In summary, this research found a fair amount of elasticity between land-use environments and commuting choices in 11 large U.S. MSAs. One public policy implication of these findings would be to encourage denser, mixed-use development, at least in those areas that are well-served by public transit, where there are reasonable options for walking and bicycling to work, and where non-auto commuting is an explicit policy objective (such as for air quality attainment purposes). Infill development and reurbanization of traditional centers represent one approach to creating viable mixed-use centers. Encouraging new mixed-use suburban enclaves and edge cities, interlinked by efficient mass transit services, might be another. The possible policy mechanisms for bringing about such changes in the built environment are numerous, ranging from coordinated regional planning of transportation and land-uses to congestion pricing and parking cash-out programs (Shoup, 1995). Of course, many factors other than the land-use environment can also have a profound impact on future commuting behavior. Finding the right combination of land-use and non-land-use (e.g. pricing) initiatives for achieving various mobility and environmental objectives remains a significant public policy challenge.

While this research concentrated on commute trips, the land-use environment, and in particular mixed uses, likely have a significant impact on non-work travel, especially shop trip-making, as well. Unfortunately, there are no national data bases, like the AHS, that contain suitable land-use and non-work travel data for examining these relationships. While land-use data can be merged with data from regional travel surveys in a metropolitan area, usually there are not enough trip records for any one neighborhood to study how land-use environments affect non-work travel at a disaggregate level. Obtaining suitable data for studying how densities and land-use mixtures shape non-work travel behavior remains a significant research challenge.

Acknowledgement—Kang-Li Wu assisted me with the data analyses presented in this paper. I alone, however, am responsible for any errors or oversights.

REFERENCES

Mixed land-uses and commuting


