WALKING AND THE BUILT ENVIRONMENT

We examine which aspects of the built and natural environment are conducive to walking by examining the relationships between walking as reported in NPTS 1995 and NHTS 2001 and neighborhood characteristics of the participant's residence. Our research is still ongoing therefore we can only present part of the results that we intend to produce.

We examine the influence of population density, and business density in proximity of survey participants' residences and we follow the applicable criteria of the "Smart Scorecard for Development Projects" of the "Congress for New Urbanism" (*1*)

The purpose of the Scorecard is to assist elected local officials, developers, investors, neighborhood groups, and designers make better project-level decisions that achieve the Smart Growth objectives. It can help evaluate whether a particular project is advancing the long-term viability of a community or creating more impacts with little overall benefit to existing and new citizens. That purpose is different from just stimulating walking; nevertheless we thought it is appropriate to evaluate that aspect of the Scorecard and subsequently produce recommendations concerning criteria for development of the built environment to stimulate walking.

Data

NPTS 1995 and NHTS 2001

The National Personal Transportation Surveys of 1995 and the National Household Transportation Surveys of 2001 each interviewed some 40,000 households including a detailed survey concerning one travel day of each household member of age 5 and over.

We have acquired access to the census block group identifiers of the address of residence of participating household and use that to link with other geographic data.

We are using the 1995 data in order to explore the relationships that may be of importance for walking and bicycling and plan to use the 2001 data for estimating a final model.

Only 10.4% of participants reported any walking trip in the 1995 survey and only 1.3% any bicycle trip.

Census data

The Census data provide the opportunity to gather block groups within a radius around participants. We use Census data on population, housing, and income distribution.

TIGER data

The TIGER data includes location data of streets by street segment and intersection, and on larger units such as block groups, cities, etc. We use the TIGER data for several measures of street patterns such as connectivity measures and average block size.

InfoUSA

The InfoUSA database includes information on location of possible destinations for trips: businesses, public buildings, and facilities. With this data set we can estimate the correlations with proximity of possible destinations. The data set is not up to date with respect to individual businesses present at the time of survey due to frequent changes of occupation of business venues but we assume that general relevant neighborhood characteristics are still well represented.

Weather data

We acquired data from the United States Historical Climatology Network (HCN) Serial Temperature and Precipitation Data from 1221 high-quality stations within the 48 contiguous United States.

Elevation data

We have the US elevation data in 100 Meter pixels from which we can derive grades. Grade influences attractiveness for walking and bicycling, as well as the amount of energy required to cover a distance.

Land use classified images from Landsat

The Land Use Land Cover dataset is based on the early to mid-1990s Landsat Thematic Mapper satellite data. It concerns a 21-class land cover automatic classification scheme applied consistently over the United States. The spatial resolution of the data is 30 meters. The automatic classification is not very accurate when compared to a gold standard based on aerial photography. We are nevertheless interested to see to what extent a global image still has a correlation with walking or bicycling after accounting for al more detailed data.

Radius/buffer

We are looking at the influence of entities described above when present within different distances from the participants' residence with radiuses of 0.25, 0.33, 0.5, 1, 1.5 and 2.5 miles.

Methods

The unit of analysis is the individual surveyed for walking in NPTS 1995 or in NHTS 2001. Neighborhood characteristics are obtained by linking the NPTS/NHTS data with other data sources. Since the assignment to neighborhood characteristics is hardly random, we adjusted to individual characteristics that might influence both the selection of environment and the physical activity of walking. The adjustment method we choose is the propensity score methodology.

Propensity score was first introduced by Rosenbaum and Rubin (*2*) for causal inference in observational studies. They showed that adjusting for differences in the propensity score between treatment and control groups can remove the biases related to the differences in pre-treatment variables. Although their study focused on binary treatment, propensity score can also be used on multi-valued treatment and this was clearly raised by Imbens (*3*).

The procedures of applying the propensity score methodology to our project is as the following:

1. Based on the Scorecard criteria, each of the measurements on neighborhood characteristics is transformed into categorical variables.
2. Each measurement is then taken as a type of “treatment”, and their different values imply different levels of treatment. There is no ordinal relationship between different levels of treatment.
3. A multinomial logistic model with a set of observed covariates is used to estimate the propensity score, the conditional probability that each observation belongs to a certain level of treatment based on observed covariates.
4. The average effect of a certain level of treatment for the population is estimated by using the inverse of the propensity score as weights for the observations in that level of treatment.
5. For each “treatment”, the estimated effects of different levels of treatment are compared to those before any adjustment. Then we could tell whether there is an observable effect of the different levels of treatment after adjusting to a set of observed covariates

We included the following measurements of neighborhood characteristics: dwelling density, proximity to businesses, business diversity, street patterns, and income distribution and propensity score correction concerns the following variables: age, gender, race/ethnicity, education level, household income, consolidated metropolitan statistical area (CMSA), household size, family life cycle, employment status, distance to work, travel day, travel month, weather (precipitation, minimum and maximum temperature of travel day), and neighborhood income distribution.

Up to now we have worked on a subset of the NPTS 1995 with participants in the 10 largest CMSAs.

We have examined the effects of the following neighborhood characteristics on walking: dwelling density at the 0.25 mile radius; population density at the 0.25 mile radius, business diversity at the 0.25 mile radius, business density at the 0.25 mile radius, and the combined effects of population density and business density at the 0.25 mile radius. Dwelling density is defined as the average number of dwelling units per acre. It is categorized as TABLE 1 shows.

Population density and business density are transferred into categorical variables on the scale of 1-6, as TABLE 2 shows. Business diversity is defined as how many types of business are in the 0.25-mile radius where the participants live. Businesses are categorized as one of the following: Service, retail, cultural, educational, recreation, neighborhood serving/retail, and employment. Each participate has a score from 0 to 7, indicating having 0 to 7 different types of businesses in the 0.25 mile radius.

Tentative Results

The relationship between population density/dwelling density and walking

Population density and dwelling density are two closely related measures. FIGURE 1 shows the trend of the probability to walk by score of dwelling density. After the adjustment to observed covariates, the trend is still obvious. About 35% of the participants in areas with "excellent density" reported at least one walking trip during the surveyed travel day. The percentage is about 3 times as much as those in the "sub-minimal" group. The trend of probability to walk by population density is similar to that by dwelling density and is even more obvious. Around 40 percent of participants in the highest category of population density reported at least one walking trip during the surveyed travel day. That is around 7.3 times as much as the percentage in the lowest category of population density.

The relationship between business density/business diversity and walking

When business density is below 4, the probability to walk doesn't change much as business density increases from 1 to 3. However, when business density is at or above 4, the probability of walk increases rapidly with the increasing business density. Participants in the group with highest business density walk around 3 times as much as those in the category of 3, and around 3.3 times as much as those in the group with lowest business density. A steady increase of the probability to walk with regard to business diversity is also observed, as FIGURE 2 shows.

The combined effects of business density and population density on walking

On the above we examined the effects of population density and business density on walking separately. We also tried to examine their combined effects on walking and the results are shown in FIGURE 3. Participants are separated into 36 groups by population density and business density. Some grids are empty because there are very few participants in that category (less than 30). From FIGURE 3 we can see that, as population density gets larger, the probability to walk increases. But the impact of business density on walking varies at different levels of population density. A U-shaped pattern between business density and walking is observed at population density levels of 2, 4 and 5. The highest probability to walk is achieved when population density is 6, and business density is 4. 48.8 percent of participants in this category reported at least one walking trip during the surveyed travel day. The lowest probability is observed in the category when population density is 1, and business density is 3. The value is only 0.012. FIGURE 3 also reveals that the change in population density has greater impact than the change in business density on the probability to walk.

References

(*1*) Fleissig W, Jacobsen V. Smart Scorecard for Development Projects. http://www.cnu.org/cnu_reports/Scorecard_exp.pdf. accessed 24 September 2004.

(*2*) Rosenbaum P, D.Rubin. The Central Role of Propensity Score in Observational Studies for Causal Effects. Biometrika 1983;70:41-55.

(*3*) Imbens G. The Role of Propensity Score in Estimating Dose-Response Functions, Technical Working Paper 237. http://www.nber.org/papers/T0237. accessed 24 September 2004.

TABLE 1 Dwelling Density Criteria

Average dwelling density (units/acre)	Category	Fraction in the population (%)
<4	Sub-minimal	74
4-6	Minimal	8
7-9	Acceptable	4
10-13	Preferred	3
14 or more	Excellent	11

TABLE 2 Population/Business Density Categories

Category Number	Target fraction in the population (%)	Density in number per acre	
		Population	Business
1	10	0 - 0.394	0
2	15	0.394 -1.394	0 -0.008
3	25	1.394 - 4.912	0.008 - 0.032
4	25	4.912 - 13.628	0.032 - 0.191
5	15	13.628 - 40.986	0.191 - 0.668
6	10	> 40.986	> 0.668

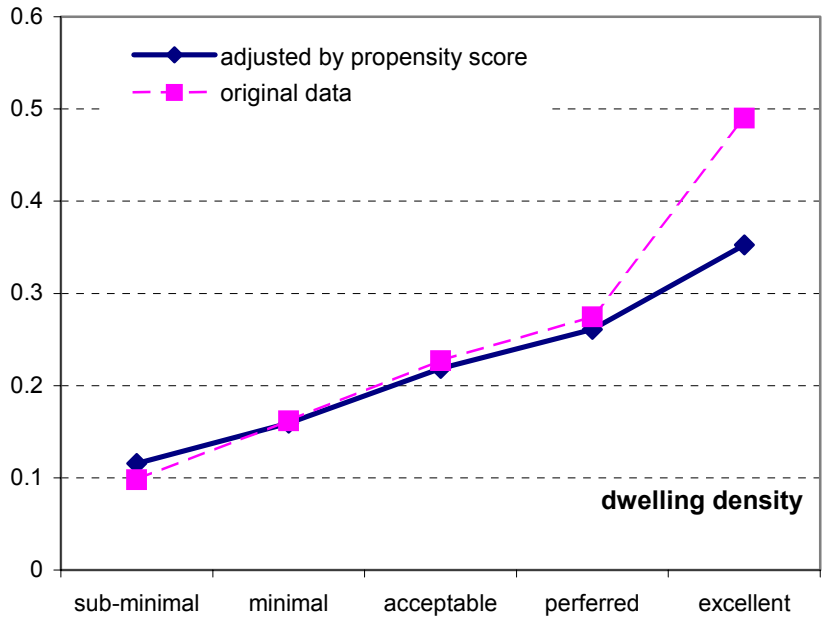

FIGURE 1 Probability to Walk by Dwelling Density

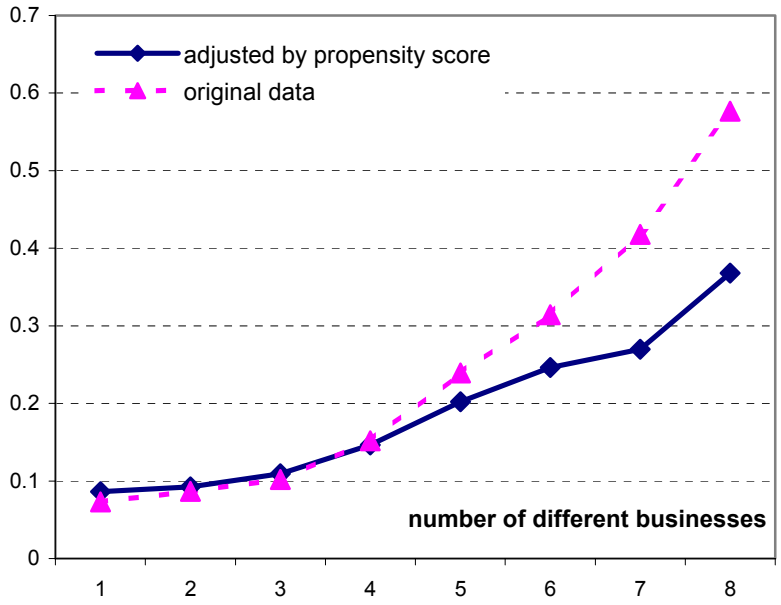

FIGURE 2 Probability to Walk by Business Diversity

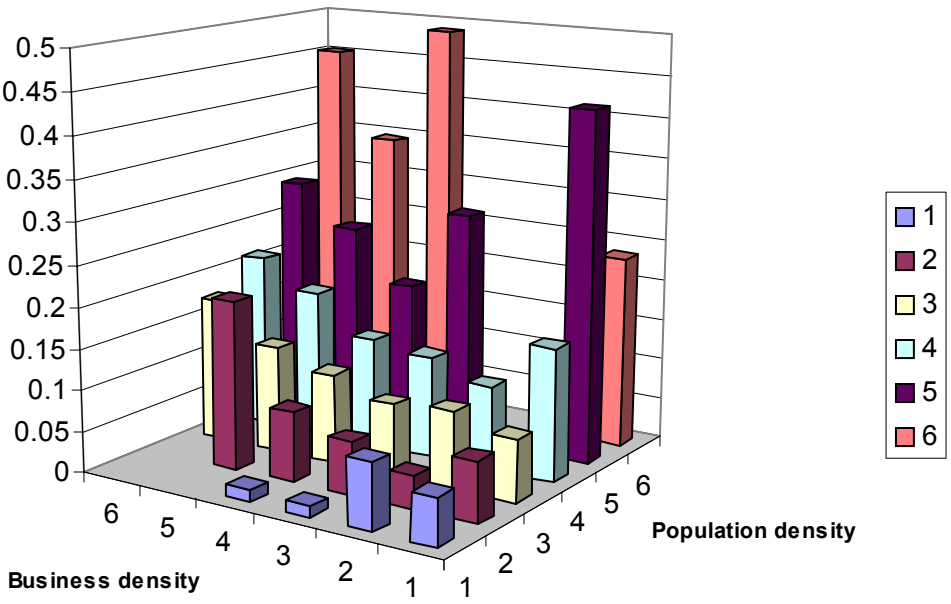

FIGURE 3 Probability to Walk by Population Density and Business Density