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Deconstructing development density: Quality, quantity and price effects on household non-work travel

Daniel G. Chatman *

Edward J. Bloustein School of Planning and Public Policy, Rutgers University, 33 Livingston Avenue, Suite 302, New Brunswick, NJ 08901, USA

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Abstract

Smart growth and transit-oriented development proponents advocate increasing the density of new land development and infill redevelopment. This is partly in order to reduce auto use, by reducing distances between trip origins and destinations, creating a more enjoyable walking environment, slowing down road travel, and increasing the market for transit. But research investigating how development density influences household travel has typically been inadequate to account for this complex set of hypotheses: it has used theoretically unjustified measures, has not accounted for spatial scale very well, and has not investigated potentially important combinations of measures. Using data from a survey of metropolitan households in California, measures of development density corresponding to the main hypotheses about how density affects travel—activity density affecting distance traveled, network load density affecting the speed of auto travel, and built form density affecting the quality of walking—are tested as independent variables in models of auto trip speed and individual non-work travel. Residential network load density is highly negatively correlated with the speed of driving, and is also highly correlated with non-work travel, both singly and in combination with other measures. Activity density and built form density are not as significantly related, on their own. These results suggest that denser development will not influence travel very much unless road level-of-service standards and parking requirements are reduced or eliminated.

Keywords: Development density; Travel behavior; Congestion; Road level-of-service standards; Built environment; Transit-oriented development

1. Introduction

The reliance of American households on their cars has received increasing political attention as urban congestion has worsened, commute durations have risen, air quality has deteriorated, and the prospect of global climate change has become more definite. In response, planning academics and practitioners have often recommended policies intended to slow or reverse "sprawl" and thus, it is hoped, to decrease auto use. Household travel decisions may indeed be influenced by built environment factors such as the distance to shops and

* Tel.: +1 732 932 3822x724; fax: +1 732 932 2253.
E-mail address: chatman@rci.rutgers.edu

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services, the structural density of buildings, transit access, and freeway capacity. But there is considerable scholarly disagreement about the nature and magnitude of such influences (Badoe and Miller, 2000; Boarnet and Crane, 2001b), despite more than a hundred empirical studies on the topic (Crane, 2000; Ewing and Cervero, 2001). One explanation for the mixed findings within the empirical literature is the lack of a clear rationale for choosing built environment measures. Development density is a central example. It is typically measured as gross population density, and sometimes as gross employment density, partly for convenience and partly guided by precedent. Pushkarev and Zupan (1977) may have initiated the tradition in their seminal study of rail and bus system performance in the New York metropolitan area, finding a strong relationship between the number of residents per gross land area and transit ridership. But the gross population density measure, problematic even in predicting markets for transit commuting, is less sensible still as a basis for understanding either non-work travel or travel by non-transit modes. Segregated residential areas have higher gross population density *ceteris paribus*, as well as possibly having less frequent transit service, fewer activities within walking distance, wider streets, and more ample parking. Gross population density may or may not be correlated with congestion, the availability of activities, or the quality of the walking environment in any given metropolitan area or sub-area, in part due to variance in the era of development, current and historical land use policies, road network capacity, and the regional economy.

Aggregate studies of household travel using cities or sub-metro areas as units of analysis have generally found an inverse relationship between development density (typically measured as gross population density) and auto use (Dunphy and Fisher, 1996; Kockelman, 1995; Newman and Kenworthy, 1999). Other recent controlled studies have found a strong correlation between urban area population density and area-wide measures of congestion (Hahn et al., 2002; Sarzynski et al., 2006). Aggregate analyses focusing on smaller areas, such as employment sites, Census tracts, and sub-cities, have generally also found correlations between gross employment or population density, higher alternative mode use, lower auto use, or lower auto ownership (e.g., Cervero, 1988; Dunphy and Fisher, 1996; Holtzclaw, 1994; Messenger and Ewing, 1996). Some of these aggregate analyses have controlled for transportation capacity measures such as freeway supply, transit supply, and freeway congestion (e.g., Cervero, 1989; Hahn et al., 2002; Sarzynski et al., 2006), but because cities are likely heterogeneous along unobserved dimensions that correlate with observed variables, these analyses may not be sufficiently controlled.

Studies using disaggregate data about individual or household travel are better able to account for heterogeneity within and between places, but such studies also have typically relied on gross population or employment density measures that may function as proxies for several unobserved correlates. These studies have sometimes found statistically significant relationships between measures of household travel and gross employment density, gross population density, or a combination of both (e.g., Boarnet and Greenwald, 2000; Boarnet and Sarmiento, 1998; Crane and Crepeau, 1998; Ewing, 1995; Frank and Pivo, 1994). However, the disaggregate studies have mixed results in comparison to aggregate studies. In some cases other land use measures (e.g., accessibility indexes) are more significant in controlled models, and the density measures are either not significant or of arguably marginal significance (Ewing et al., 1996; Kockelman, 1995; Levinson and Kumar, 1997; Pickrell and Schimek, as reported in Pickrell, 1999; Schimek, 1996; Sun et al., 1998).

Gross population density is the standard measure, but in fact measuring development density presents a complex set of choices (Churchman, 1999): different numerators (e.g., structures, population, employment by type, roads), different divisors (e.g., gross land area, land area net of roads and parking, developed land area, land area by development type, transportation network capacity), and scales ranging from the Census block to the metropolitan area. Choosing from this potential set of measures should be systematic rather than based on convenience, as different density types can be expected to have qualitatively and quantitatively different effects on available travel choices.

Even methodologically sophisticated and recent research has tended to use population density or net residential density in an *ad hoc* fashion, either to represent several hypothesized effects simultaneously or merely as a control variable without clear justification (e.g., Boarnet and Greenwald, 2000; Frank et al., 2004; Giuliano and Narayan, 2003; Naess, 2006; Schimek, 1996). And though smaller areas are likely to matter more for non-motorized travel than for auto and bus travel, only recently has there been any systematic attention paid to scale when measuring the built environment's relationship with different modes of travel (Zhang and Kukadia, 2005).