Original Article

The economic value of walkable neighborhoods

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Abstract This study investigated how the benefits of a walkable neighborhood were reflected in the American real estate market by examining the economic values of urban environmental factors supporting walking activities. Property values were used as a proxy measure for economic value and analyzed in relation to land use characteristics that have been known to correlate with walking at the neighborhood scale. Four aspects of the built environment supporting walking were included in the analyses: development density, land use mix, public open space and pedestrian infrastructure. Hedonic models were employed where the property value was regressed on the measures of the four sets of correlates of walking in a neighborhood. Models were estimated for four land use types – single-family residential, rental multi-family residential, commercial and office. The findings did not support previous arguments that increasing density weakens the quality of a neighborhood. To the contrary, the positive association of higher development density with the value of single-family residential properties detected in King County suggested that high development density might increase surrounding property values. The pedestrian infrastructure and land use mix significantly contributed to increases in rental multi-family residential property values. Higher development density with higher street and sidewalk coverage were also favored by retail service uses. In relation to land use mix, mixing retail service uses and rental multi-family residential uses helped make rental housings more attractive.
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Introduction

The concept of walkable neighborhood is at the core of such contemporary urban theories as Smart Growth and New Urbanism. Proponents of these approaches argue that building walkable communities will counteract the negative effects of urban sprawl and alleviate traffic congestion, air pollution, and the destruction of natural environments in and near metropolitan areas (Paumier, 2004). Researchers have claimed that combining residential and commercial land uses in walkable neighborhoods will help produce such social benefits as affordable housing (Hess and Lombardi, 2004; Handy, 2005), cleaner air and water (Shapiro *et al*, 2002) and lower automobile dependency (Dorn, 2004).

Other researchers have expressed doubts about the viability of walkable neighborhoods as an alternative to sprawl. They assert that consumers do not care about such social benefits, simply favoring higher standards of living such as more room and spacious yards filled with trees and shrubs, and that traditional auto-oriented suburban developments have successfully competed in the market place (Holcombe, 1999). They add that citizens are so accustomed to auto-oriented suburban space that the market for walkable urban settings is limited.

This study addressed these issues by examining the economic value of walking friendly urban environments. Property values were used as a proxy measure for economic value and analyzed in relation to land use characteristics that have been shown to correlate with walking at the neighborhood scale. The approach assumed that assessed property values were associated with consumers' willingness to pay, and thus reflected consumers' like or dislikes of neighborhood features supporting walking.

Four aspects of the built environment supporting walking in a neighborhood were included in the analyses: development density, land use mix, public open space and pedestrian infrastructure. Hedonic models[1] were employed where the property value was regressed on the measures of the four sets of correlates of walking in a neighborhood. Models were estimated for four land use types – single-family residential, rental multi-family residential, commercial and office.

Background

A walkable neighborhood: Built environment correlates of walking

A large body of literature in transportation and health has documented walkable neighborhoods as being characterized by medium- to high-density residential development, a mixture of land uses that are close together to reduce or eliminate the need to drive between routine activities. Specifically, improved accessibility to retail stores, transit and recreational areas has been associated with more walking (Katz, 1994; Crane and Crepeau, 1998; Limanond and Niemeier, 2003; Morrow-Jones *et al*, 2004; Giles-Corti *et al*, 2005; Song, 2005; Moudon *et al*, 2007). Saelens and Handy (2008) conducted a systematic review of articles examining the link between built environment and walking. Their review identified several correlates of walking with sufficient evidence. According to the results, development density, mixed land use and the pedestrian transportation infrastructure were found to be associated with walking. In contrast, few studies reported associations between parks and open space and walking (Clifton and Dill, 2005; Giles-Corti *et al*, 2005; Zlot and Schmid, 2005), whereas others found no evidence of such a relationship (Bopp *et al*, 2006; Lee and Moudon, 2006).

Among these various factors related to walking, this study focused on the four sets of correlates of walking shown in Table 1.

Economic value of walkable neighborhoods

Research on the economic benefits of walkable neighborhoods has remained limited to how selected aspects of walkability might be acknowledged in the real estate market.

Residential density has been considered to undermine the quality of a neighborhood, and thus to decrease the values of residential properties. Most studies confirmed that the residential real estate market did not favor urban environments with high development density (Schwanen and Mokhtarian, 2004). On the basis of a preference survey in which consumers were conditioned by the respondent's stage in the life cycle, length of residence and socio-psychological factors, Talen (2001) reported that Americans preferred low-density suburban development over urban life. Song and Knaap (2003) also noted that density – measured by single-family residential dwelling unit density and population density – was negatively related to the housing values in the Portland, OR, region, suggesting consumers' preference for lower density single-family neighborhoods.

Other research found evidence that certain groups of people were willing to pay a premium to live in compact environments. A comparative study conducted by Eppli and Tu (1999) examined four New Urbanist communities and found that there was a price premium of about 15 per cent to live in a New Urbanist (or neo-traditional) community over a comparable conventional suburban subdivision. Lang *et al* (1997) claimed that such a phenomenon represented the existence of dual housing markets: one for conventional low-density suburbs, and one for cities and denser suburbs.

While the positive effects of mixing land uses on walking trips (that is, by reducing the travel distances to destinations and by increasing diversity of amenities) have been demonstrated, the findings of research on the market reaction to land use mix have been inconclusive. For example, Grether and Mieszkowski (1980) conducted market experiments designed to produce measures of the effects of nonresidential land uses on the prices of nearby dwellings, but found no systematic relationship between nonresidential land use and housing prices. Later, Cao and Cory (1981) examined the relationship between non-residential uses and residential property values. They also noted that the effect of non-residential activity on property value was indeterminate and influenced by the external effects generated from the nonresidential activities. Later, Sohn and Moudon (2008) analyzed the effects of land use mix on the value of office properties in King

Table 1: The correlates of walking for the investigation

The correlates of walking	*Relations with walking*	*Reference*	*Findings*
Development density	In areas with higher density, destinations can be closer meaning that the needs for driving decrease	Gauvin *et al*, 2005	Positive relation of walking to density of destinations
		Clifton and Dill, 2005	Greater walk trips with increasing housing density
		Khattak and Rodriquez (2005)	Higher walking trips in neo-traditional versus conventional neighborhood
Land use mix	By putting various amenities in close proximity to one another, walking becomes viable	Lee and Moudon, 2006	Positive relations between walking and close proximity to a grocery store, eating places and retails
		De Bourdeaudhuij *et al*, 2005	Walking for transport related to higher land use mix
		Hoehner *et al*, 2005	Walking for transport related to greater perceived and objective land use mix
Public open space	It supports walking by offering opportunities for recreation and improving environmental quality of a neighborhood	Giles-Corti *et al*, 2005	High walking more likely among individuals with shorter distance to highly attractive and large public open space
		Clifton and Dill, 2005	Greater walk trips with greater park access (men only)
		Zlot and Schmid, 2005	Walking for transport related to parkland acreage
Pedestrian infrastructure	Small street blocks shorten distances between activities, making walking practical. Wide sidewalks and safe opportunities to cross streets obviously support walking by creating safe environments	Cao and Cory, 1981	Higher walking to store frequency related to route comfort and pedestrian connections
		Li *et al*, 2005	Higher walking activity among residents in neighborhoods with more street intersections
		Fulton *et al*, 2005	Higher walk for transport to school among residents of areas with sidewalks

County, WA. This study found that office property values in the office cluster decreased as the proportion of surrounding land in retail uses increased, which suggested that urban planning policies seeking to mix uses in employment centers were not supported by current market trends.

A few studies have tried to measure the impact of pedestrian infrastructure on the values of nearby properties. Asabere (1990) estimated the effects of neighborhood street patterns on housing values using data from Halifax, Nova Scotia. Using two categories of streets – cul-de-sac and grid – the study found that cul-de-sacs generated a 29 per cent price premium over the grid street pattern, supporting the hypothesis that cul-de-sacs attracted premium values. In contrast, Plaut and Boarnet (2003) studied New-Urbanism-style neighborhoods characterized by a grid street pattern and street-oriented neighborhood design and found that housing sales data attributed a significant price premium to New-Urbanism-style neighborhoods.

Regarding public open space, studies generally confirmed that residential property values increased with the nearby presence of open space. For example, Irwin (2002) estimated the marginal value of different open space attributes using a hedonic pricing model with residential sales data from central Maryland. He found that surrounding open space significantly influenced the residential sales price of houses. More recently, researchers (Laverne and Winson-Geideman, 2003; Wolf, 2003) noted that commercial properties might benefit from attributes related to open space such as a quality landscape and greenery.

In summary, previous studies found that aspects of land use and the built environment associated with walking were valued in the real estate market. Evidence of such valuation, however, remained mixed. More comprehensive and detailed analyses would be needed to understand the spatial characteristics of walkable built environments that can be supported in the market.

This study sought to add to the evidence with an individual property level analysis of the relationships between both residential and commercial property values and the primary physical characteristics of environments that support walking.

Methods

Research design

This research examined the economic value of neighborhood walkability. It was conducted at the individual level for properties located in the urban growth area (UGA) of King County, WA. First established in 1985, King County's UGA has been used to limit growth to areas with an existing infrastructure for facilities and services. The City of Seattle and major suburban cities of the region such as Bellevue, Kirkland and Redmond are located within the boundary of UGA. More than 93 per cent of new housing in the region has been built in the urban growth area from 1994 to 2001 based on building permits issued by the cities and King County.

For each individual property, the measured characteristics of walkability included development density, land use mix, public open space and pedestrian infrastructure. Economic value was measured by the assessed property value of individual properties in four different land use types: single-family residential, rental multi-family residential, retail service and office uses.

The use of readily available data at the parcel level[2] (the finest resolution of the built environment) with the GIS based neighborhood analysis techniques helped bypass the modifiable areal unit problem (MAUP)[3] derived from data aggregation. The potential model bias because of the spatial autocorrelation[4] in the property value data was checked using the Moran's Index test.[5]

Data and sampling

The parcel level property related data sets, which were the primary data for the analysis, came from two primary sources: (i) a parcel level data set in GIS obtained from Washington State Geospatial Data Archive provided basic attributes of individual parcels, such as parcel boundary and size. (ii) The parcel level tax assessment data set from the King County Department of Assessments included the land's and the building's assessed value information in addition to the detailed description of the parcels and their development status such as land use types, physical attributes of buildings (for example, number of bedrooms, number of bathrooms, fireplace, floor area ratio (FAR), building square footage, building quality and so on) and other miscellaneous information on individual parcels. Both data sets were obtained in 2004.

In addition, a variety of data sets in GIS were used for measuring physical and socio-demographic characteristics of a neighborhood. Table 2 shows the list of the GIS data sets with the brief descriptions.

The sample parcels for this study were selected from the individual parcel records available within the 500 square mile (1310 km^2) Urban Growth Boundary (UGB) area of King County, Washington. The county's UGB served to define the urbanized area because it contained most of the developed land (with 95 per cent of the residential units). The sample parcels were randomly selected using a GIS program (Arcview GIS Arcscript – simplers.avx designed by William Huber). Among all parcels in the King County UGB 2289 samples of single-family residential, 837 samples of rental multi-family residential, 738 samples of retail service and 586 samples of office parcels were randomly selected by the sampling process. The distribution of the sampled parcels for the four land uses is illustrated in Figure 1.

Dependent variable

Two dependent variables – (i) the logged total assessed value of land and improvement per parcel (for single-family residential, retail service

Table 2: List of data sets in GIS

Data set	*Data type*	*Source*	*Description*
parks.shp	Polygon shape file	King County Department of Transportation (2004)	• Delineates the locations and boundaries of public parks in King County, along with their names
streets.shp	Line shape file	King County Department of Transportation (2004)	• The centerlines of the street network in King County • provide detailed information on the status of individual street segments (for example, length, width, road class and so on).
sidewalks.shp	Line shape file	Puget Sound Regional County (2000)	• Provides information on the location and length of sidewalks available in the region.
busstops.shp	Point shape file	King County Department of Transportation (2000)	• Provides the locations of bus stops available in the region.
urban centers.shp	Polygon shape file	Puget Sound Regional County (2004)	• Delineates the boundary of Seattle downtown and urban centers designated in PSRC Vision, 2020
Block group level census data set	Polygon shape file	US Census Bureau (2000)	• The block group level data of average total household income, median age of households and per cent of non-White households

and office models), and (ii) the logged total assessed value of land and improvement per residential unit (for rental multi-family residential model) – were used as a proxy for a property's market value.

In Washington State, assessment for tax purposes required establishing the full market value of a parcel of land and its improvements; therefore, the total valuation of the properties in the data represents 100 per cent of the fair market values (Department of Assessments, King County, WA). The County's analytical method of property assessment has been known to be reliable to capture the market value of properties (Clapp and Giaccotto, 1992; Janssen and Soderberg, 1999).

Measuring neighborhood walkability

Defining the spatial boundary of a neighborhood

Neighborhood boundaries needed to correspond to the spatial range of people's walking behaviors. Several studies provided useful information for determining the spatial boundary of a neighborhood affecting people's walking and transit behavior. Ewing (1995) reported that people walked an average of 0.3 miles for shopping trips, 0.28 miles for accessing transit stops and family businesses based on 1990 National Personal Transportation Survey data and an average walking speed of 3.16 mph. A case study conducted by the Federal Highway Administration (FHWA) to build transit catchment areas for determining walking accessibility to transit stops used one-quarter mile as the maximum distance that riders feel convenient to walk (FHWA, 2002). Other studies examining pedestrian travel patterns also used one-quarter mile or a 5 to 10 min walking distance for defining the extent of a neighborhood (Rood, 2000; Dill, 2003). Overall, studies confirmed that walking distances ranged between 0.25 and 0.3 miles. Given the focus of this study on measuring correlates of walking in a neighborhood and on assessing the impacts of these correlates on property values, a one-quarter mile radius airline buffer around the sampled parcels was adopted as the spatial boundary of a neighborhood (Figure 2).

Using a circular buffer around a sampled parcel as the spatial unit of analysis had the advantage of avoiding data redundancy derived from the use of a larger predefined spatial unit such as a census tract or transportation analysis zone as the boundary of the spatial analysis (Sohn, 2007). For example, given that two samples were located in the same census tract (first figure of Figure 3), using a census tract as the boundary of a neighborhood produced the same value of a neighborhood measure for the two samples as they had the same neighborhood boundary. On the other hand, defining a neighborhood as the buffer area around each sample (second figure of Figure 3) produced a unique value of a neighborhood measure for each of the samples, thus

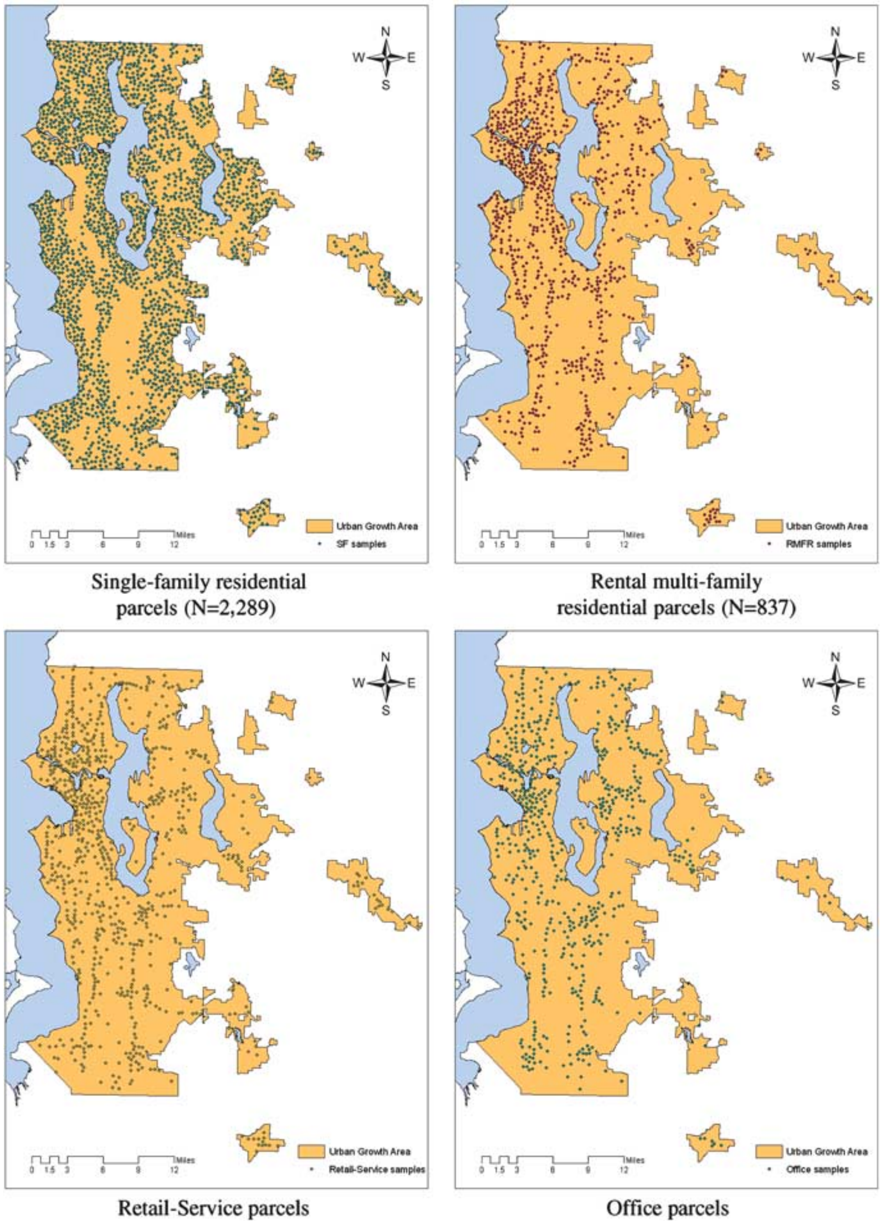

Figure 1: Maps of the distributions of sampled parcels.

clearly differentiating between them based on their neighborhood boundaries.

Measuring built environment correlates of walking

The independent variables of interest in this study, which are development density, land use mix, open space and pedestrian infrastructure (Table 3), were measured in different ways by different researchers. Various forms of density measures were extensively used in the travel behavior research because density was one of the core characteristics of built environments (Cervero, 2002). Most frequently, density was estimated in the form of residential density (for example, Giuliano and Small, 1993; Rajamani *et al*, 2003) or employment density (Cervero, 1996; Kockelman, 1997; Anderson and Bogart, 2001). A major shortcoming of these two measures was that they were only able to capture the density of specific land uses (residential or commercial uses). On the other hand, development density

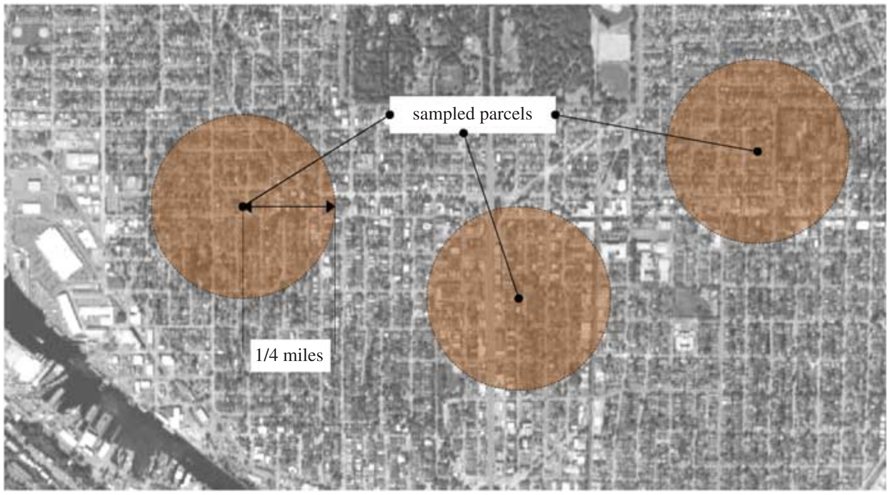

Figure 2: Illustration of the suggested spatial unit of analysis for the neighborhood analysis.

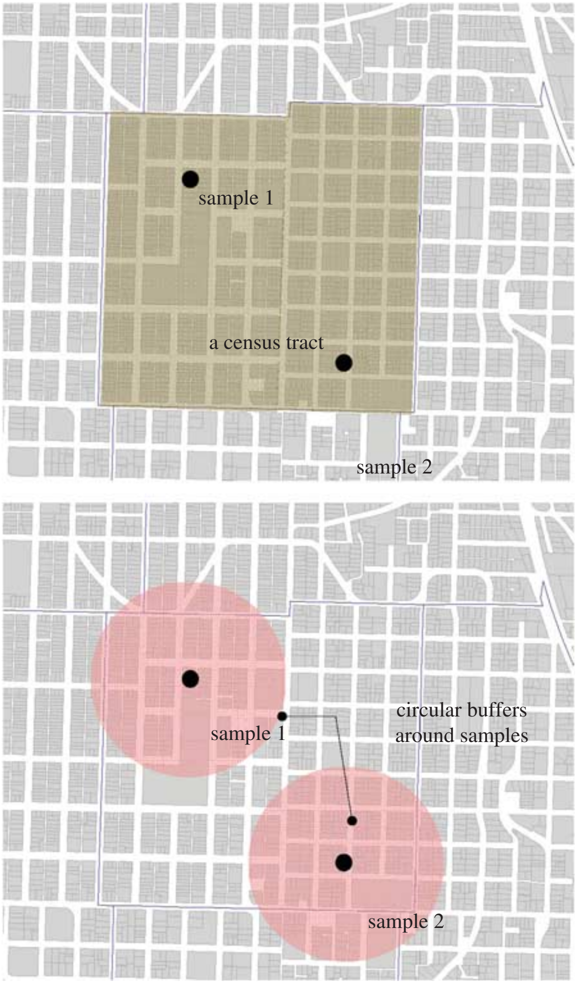

Figure 3: Comparison of the spatial units of analysis (census tract versus a circular buffer around a sample).

was, by definition, capable of capturing a neighborhood's overall physical density level regardless of land use types. For this reason, the average FAR in a neighborhood was used in the models as a measure of development density.

Mixed land use and open space were also important built environment correlates of walking. As they were associated with land use patterns, the characteristics of these two correlates could be captured by measures describing the type and intensity of land uses. In addition, they were also associated with proximity to potential destinations – mixed land use (including open space) meant that destinations were within close proximity – proximity to destinations was known to be the most consistent correlate of walking (Saelens and Handy, 2008).

Most frequently used measures associated with land use mix were heterogeneity and diversity measures. An entropy index and a dissimilarity index estimated the degree of uniformity of land uses or the degree to which different land uses came into contact with one another. The shortcoming of these measures was that they were not able to capture the difference of specific land use composition such as a mixed land use of 30 per cent residential and 70 per cent retail versus a mix of 30 per cent in retail and 70 per cent in residential uses (Hess *et al*, 2001; Krizek, 2003). As an alternative way, this research estimated the proportion of specific land use area in a neighborhood. This measure enabled to conduct more detailed analysis for the degree of land usage for specific uses and their interactions. In addition, average Euclidean distance from sampled

Table 3: The list of the measure for the correlates of walking

Correlates of walking	*Measurement*	*Unit of measures*	*Description*
Development density	Average FAR	—	Average floor area ratio of all developed parcels in a neighborhood
Land use mix	Ratio of MF area	%	Ratio of the area of multi-family residential parcels in a neighborhood to the total area of a neighborhood
	Ratio of retail service area	%	Ratio of the area of retail service parcels in a neighborhood to the total area of a neighborhood
	Ratio of office area	%	Ratio of the area of office parcels in a neighborhood to the total area of a neighborhood
	Average distance to MF uses	ft	Average distance to the MF parcels in a neighborhood
	Average distance to retail service uses	ft	Average distance to the retail-service parcels in a neighborhood
	Average distance to office uses	ft	Average distance to the office parcels in a neighborhood
Public open space	Distance to public open space	ft	Distance to the closest public park in a neighborhood
Pedestrian infrastructure	Distance to a bus stop	ft	Distance to the closest bus stop in a neighborhood
	Street density	ft/acre	Ratio of the length of streets in ft to the acreage of a neighborhood
	Sidewalk density	ft/acre	Ratio of the length of sidewalks in ft to the acreage of a neighborhood

properties to surrounding uses were estimated as it was the simplest and the most extensively used measure for proximity to destinations (for example, Komanoff and Roelofs, 1993; Smith and Butcher, 1994; Handy, 1996; Talen, 2003).

The characteristics of pedestrian infrastructure were measured in the perspective of its transit accessibility and network connectivity. For measuring accessibility to transit facilities such as bus stops, train stations and trails, Euclidean distance has been commonly used (Kitamura *et al*, 1997; Kim and Ulfarsson, 2004; Song, 2005). This research employed it to measure accessibility from a sampled property to a bus stop. Although network distance, which is defined as the length of walkways from the pedestrian's origin to a destination, may be a more accurate measure for pedestrian accessibility, it was not used in this study as a large portion of the study area included low density neighborhoods with poor sidewalk infrastructure. When estimating pedestrian accessibility in these urban settings, Euclidean distance seemed to reflect pedestrian accessibility more effectively than network distance, considering pedestrians' tendency to take shorter routes by walking through undeveloped lands or along streets with no sidewalks.

The characteristics of street configuration proved to significantly affect walking and were extensively investigated in transportation research. Measures such as the linear length of streets, street density, cul-de-sac density and intersection density were developed for capturing the characteristics of street configuration in the literature (AultmanHall *et al*, 1997; Cervero and Kockelman, 1997; Srinivasan, 2001; Song and Knaap, 2004). This research employed two street density measures for sidewalks and local streets (total length of streets or sidewalks per acre). Although including more discriminative measures describing route directness would lead to a more detailed examination of the effects of street configurations on property values, it called for a non-systematic analysis (that is, visual inspection and partially subjective decision making) of each sample. Considering the large sample size, this was almost impracticable and therefore these measures were not estimated.

Control variables

The effect of neighborhood walkability was expected to be confounded by other factors determining the economic value of a property. Fundamental attributes of property value such as lot size, age of building and building square footage were considered in the model. Regional location factors were also taken into account, and measured by: (i) the distance to Seattle downtown, and (ii) the distance to the closest urban center.[6] In addition, three socio-demographic variables were included based on US Census block group data: household income, median household age and percentage of non-White residents in the neighborhood. Each of these measures was calculated by averaging the values of the census data overlapping each property's designated neighborhood (that is, quarter-mile buffer), accounting for the proportion of the block group areas contained within the neighborhood.

$$V = \sum_{1}^{n} (a_1 v_1 + a_2 v_2 + \ldots\ldots a_n v_n)$$

where, V: socio-demographic measure of a neighborhood; a: the ratio of the area of the census block group to the total area of a neighborhood; v: the value of the socio-demographic measure from a unit of census block group; n: total number of census block groups overlapping a neighborhood

The hedonic model

Variables capturing the correlates of walking, control variables and dependent variables for the four sets of hedonic model (MF, RMF, retail service and office) are listed in Table 4.

Moran's Index test was conducted to ensure that the spatial autocorrelation of sampled property values was properly controlled in the model.

Model Results

The sample size ranged from 586 office properties to 2289 single-family properties. The results of Moran's Index test showed that the spatial autocorrelation of the residuals for all models was marginal (Moran's Indexes were less than 0.01 with z-scores less than 1.96), confirming that the spatial autocorrelation of the sampled property value data was sufficiently explained by the independent variables. The test for multi-collinearity showed that variance inflation factor values below 10,[7] indicating multi-collinearity in the model was not an issue.

The explanatory power of the four sets of hedonic model varied. The office model had the highest adjusted R^2 (0.824), followed by retail service (0.724), RMF (0.574) and SF (0.357). Control variables related to the physical attributes of a property were significant for all models. The effect of ratio of non-White residents and proximity to downtown were also consistent. On the other hand, the correlates between the neighborhood-scale measures of walking and property values were noticeably different among the four models. The detailed model results are reported in Table 5.

Relationships between property values and correlates of walking

The measure of development density (the average FAR) was significantly associated with the property values of single-family residential, retail service and office uses, but not of multi-family land uses. The positive direction of the relationship indicated that higher development density increased the economic value of a property.

The measures of land use mix barely showed significant associations with single-family residential, retail service and office property values. On the other hand, three measures of land use mix – proximity to office use, proximity to retail service use, and the ratio of retail service area to the total area of a neighborhood – were found to be significantly associated with rental multi-family residential property values. The signs for proximity measures showed that the values of retail service properties increased as the proximity to office use increased (that is, the average distance to office use decreased), while they decreased as the proximity to retail service increased (that is, the average distance to retail service use decreased).

The relation between rental multi-family residential use and retail service, however, seemed complicated. Whereas proximity to retail service was negatively associated with assessed property value for rental housing, the areal increase in neighborhood retail service was positively associated with an increase in the values of rental multi-family residential parcels, meaning that a larger retail service area in a neighborhood was economically beneficial to multi-family properties.

Proximity to open space was significantly and positively associated with single-family residential property values, but did not affect property

Table 4: Summary of variables used in the hedonic model

Variable			*Name*	*Description*	*Unit of measures*
Dependent Variable			Total value[a]	Property values (land value + improvement value) logged	Log($)
			Value per dwelling unit[b]	Property value per unit (land value per unit + improvement value per unit) logged	Log($)
Independent Variables	Measures for the correlates of walking	Development density	Average FAR	The average floor area ratio of all developed parcels in a neighborhood (logged)	Log(FAR)
		Land use mix	Average distance to MF parcels	The average distance to all MF parcels in a neighborhood (logged)	Log(ft)
			Average distance to retail service parcels	The average distance to all retail service parcels in a neighborhood (logged)	Log(ft)
			Average distance to office parcels	The average distance to all office parcels in a neighborhood (logged)	Log(ft)
			Ratio of MF parcel areas	The ratio of MF parcel areas to the total area of a neighborhood	%
			Ratio of retail service parcel areas	The ratio of retail service parcel areas to the total area of a neighborhood	%
			Ratio of office parcel areas	The ratio of office parcel areas to the total area of a neighborhood	%
		Public open space	Distance to a public park	The distance to the closest public park in a neighborhood (logged)	Log(ft)
		Pedestrian infrastructure	Distance to a bus stop	The distance to the closest bus stop (logged)	Log(ft)
			Street length per acre	The length of streets per acre of a neighborhood	ft/acre
			Sidewalk length per acre	The length of sidewalks per acre of a neighborhood	ft/acre
	Control variables	Physical attributes of a property	Parcel size	Parcel size in square feet	Log(sqft)
			Building square footage	Building square footage	Log(sqft)
			Parcel size per dwelling unit[b]	Area of a parcel per unit (logged)	Log(sqft)
			Building square footage per dwelling unit[b]	Building square footage per unit (logged)	Log(sqft)
			Year built	Year built	Year
		Socio-demographic characteristics of a neighborhood	Average income of household	The average household income in a neighborhood (logged)	Log($)
			Average age of household	The average age of households in a neighborhood	Age
			Ratio of non-White residents	The ratio of non-White to White residents in a neighborhood (logged)	Log(%)
		Regional location	Distance to downtown	The distance to Seattle downtown (logged)	Log(ft)
			Distance to an urban center	The distance to the closest urban center (logged)	Log(ft)

[a]applied only for SF, retail service and office models.
[b]applied only for RMF model.

Table 5: Hedonic model results

Land use types	*Single-family residential*	*Rental multi-family residential*	*Retail service*	*Office*
Dependent variable	Property value (land value + improvement value) logged	Property value per unit (land value per unit + improvement value per unit) logged	Property value (land value + improvement value) logged	Property value (land value + improvement value) logged
N	2289	837	738	586
Adjusted R^2	0.357	0.574	0.724	0.824
Independent variable (Standardized coefficients)	*β (Significance)*	*β (Significance)*	*β (Significance)*	*β (Significance)*
Average FAR	0.116***	0.057	0.157***	0.062*
Average distance to MF parcels	0.065*	0.043	0.058	−0.023
Average distance to retail-service parcels	0.025	0.139***	−0.052	0.012
Average distance to office parcels	0.034	−0.136***	0.030	−0.022
Ratio of MF parcel areas	−0.001	−0.026	0.043	−0.038
Ratio of retail-service parcel areas	−0.018	0.091**	0.015	−0.008
Ratio of office parcel areas	0.018	0.002	−0.031	−0.002
Distance to a public park	−0.030*	0.017	−0.029	0.011
Distance to a bus stop	0.028	−0.073***	−0.015	0.010
Street length per acre	−0.018	0.102***	−0.069***	−0.086***
Sidewalk length per acre	0.013	0.080***	0.062***	−0.026
Parcel size (or parcel size per dwelling Unit[1])	0.103***	0.304***	0.402***	0.236***
Building square footage (or building square footage per dwelling Unit[2])	0.388***	0.480***	0.420***	0.593***
Year built	0.204***	0.169***	0.132***	0.104***
Average income of household	0.054***	−0.041	−0.007	0.045***
Average age of household	0.046**	−0.118***	−0.055***	0.024
Ratio of non-White residents	−0.152***	−0.375***	−0.099***	−0.065***
Distance to downtown	−0.349***	−0.479***	−0.177***	−0.115***
Distance to an urban center	−0.007	−0.011	−0.071***	−0.054***

1 & 2: applied only for rental multi-family residential model.
*significant at 0.1 level; **significant at 0.05 level; ***significant at 0.01 level.

values of rental multi-family residential, retail service, and office uses.

Several measures of the pedestrian infrastructure were found to be positively related to property values. First, proximity to bus stops contributed to an increase in rental multi-family residential property values. However, the coefficients for the other three uses were not statistically significant. Second, better sidewalk coverage in their neighborhood was positively related to increasing property values of rental multi-family residential and retail service uses. Third, street density, measured as street length per acre, showed mixed results. It is positively related to the property value of rental multi-family residential use, whereas negatively related to the property values of retail service and office uses.

Control variables

The significance levels and signs of the relationships between property values and the physical attributes of a property were fairly consistent and in the expected direction. Building square footage was the strongest correlate of property values among all independent variables in the model. Average household income in a neighborhood was positively related to single-family residential and office property values. The average household age was a significant correlate of property values for single-family residential, rental multi-family residential and retail service parcels. The direction of the association, however, varied by land use types. Whereas rental multi-family residential and retail service uses favored a neighborhood with younger households, the opposite was true for single-family residential use. Racial composition mattered for all land use types, and its effect on property values was strong. Property values decreased as the percentage of non-White residents in a neighborhood increased. Proximity to Seattle Downtown was significant in all models. Proximity to the Urban Center was also significantly related to property values for retail service and office parcels; the magnitude of its relation to property values, however, was not as great as the proximity to Seattle Downtown.

Conclusions

The findings of this study suggest the following conclusions. First, although it was obvious that most of the variation in property values was explained by the attributes of individual properties, the neighborhood's socio-demographic factors and regional location factors, some physical characteristics of neighborhoods had significant effects on individual property values. In particular, the effects of a neighborhood's racial composition (the per cent of non-White residents) and accessibility to the downtown (the distance from the downtown) were substantial.

The study also demonstrated that certain land use types were more sensitive to neighborhood walkability than others. For example, several measures of the pedestrian infrastructure and land use mix significantly contributed to increases in rental multi-family residential property values. Retail service uses also favored higher development density with higher street and sidewalk coverage. In contrast, few measures of the correlates of walking were significantly associated with single-family residential and office property values.

In relation to land use mix, the study showed that for mixed-use neighborhoods, identifying desirable land use combinations was as crucial as formulating approaches to the spatial assignment of land uses. It revealed that mixing retail service uses and rental multi-family residential used helped make rental housings more attractive. However, the positive interaction between retail service and rental multi-family residential uses could be anticipated only if these two uses were appropriately separated. Providing sufficient buffer space between rental multi-family residential area and retail service area would prevent the negative interaction between these two uses, making the rental multi-family residential properties more marketable. The study also suggests that mixing jobs with compact rental multi-family housings could be favored in the market as the findings showed a positive relationship between the values of rental multi-family residential properties and the proximity to office parcels.

More importantly, in the present study, a higher development density in a neighborhood did not always seem to affect the marketability of residential properties in a negative way although increased density has been considered as one of the main reasons for weakening the quality of a neighborhood. To the contrary, the positive association of higher development density with the value of single-family residential properties supports Eppli and Tu's (1999) claim that market demand existed for higher density neighborhoods. Further research investigating the factors making high-density neighborhoods an attractive living environment would help develop urban design strategies for creating walking-friendly urban settings that are marketable.

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Notes

1 Hedonic model is a regression analysis used to estimate economic values of components that directly affect market prices of an item. It is commonly applied to variations in housing prices that reflect the value of local environmental attributes.
2 GIS data consist of shape files defining the boundaries of parcels and tables containing information on the land uses and building attributes in the parcels.
3 The MAUP is a potential source of error that can affect spatial studies, which utilize aggregate data sources (Unwin, 1996).
4 Spatial autocorrelation refers to the pattern in which observations from nearby locations are more likely to have similar magnitude than by chance alone (Legendre and Fortin, 1989), which introduces deviation from the independent observation assumption of classical statistics.
5 Moran's Index is a measure of spatial autocorrelation developed by Patrick A.P. Moran. The values can be transformed to *z*-scores in which values greater than 1.96 or smaller than −1.96 indicate spatial autocorrelation significant at 0.05 level.
6 Urban centers, designated by Puget Sound Regional Council (PSRC) as the region's core of current and future development in Vision 2020, are locations that include a dense mix of business, commercial, residential and cultural activity within a compact area of up to 1.5 square miles.
7 the cutoff for potential multicollinearity (Myers, 1990).

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