Place-making and performance: the impact of walkable built environments on business performance in Phoenix and Boston

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Abstract

This paper examines the importance of place-making in economic development by evaluating the relationship between specific urban design features – based on Jacobs' "four generators of diversity" (1961) and Ewing and Cervero's "Five-D's" (2010) – and business sales volume. Despite the increased recognition of the importance of walkable urbanism in recent years, relatively little research has assessed the potential economic development benefits of walkable places. While a few authors have assessed the impact of urban design on property values, this paper fills a gap by examining links between components of walkable built environments and individual business characteristics. This paper uses a Hierarchical Linear Modeling (HLM) framework to explicitly look at the relationship between neighborhood built environment features at the Census tract level and the sales volume per employee of individual businesses in 2010. The cities of Phoenix and Boston are used as contrasting study sites in order to inspect how larger regional characteristics influence the built environment-performance link. The results indicate that specific features of walkable built environments are positively associated with business performance. However, the relationship between walkable built environments and business performance varies considerably depending on the type of business and city-level context being studied, indicating that significant nuance must be used when considering place-based economic interventions. Although no causal statements can be made about the built environment and business performance, the results of this paper indicate that (in some contexts) design-based place-making initiatives could be used to generate sustainable local economic development.

Introduction

Urban design and place-making are linked via the opportunities good urban design creates for people to interact with one another and the urban environment (Knox, 2005). Built environment characteristics of urban spaces such as block length, street network layout, building scale, and age provide opportunities for people to interact with one another and explore urban environments on foot. While prior work has acknowledged the importance of urban design to place making and the slow city movement (Knox, 2005; Mayer and Knox, 2006), and urban design as a critical facet of street traffic and the patronization of third places (Knox, 2005), few studies have evaluated how built environment features might also enhance business performance. This is important to consider, because it suggests there are both aesthetic and economic benefits to good urban design.

Previous work on the economic value of good urban design has evaluated the linkages between walkability and property values. (Leinberger and Alfonzo 2012; Pivo and Fisher 2011; Li et al. 2014). While valuable, these studies do not consider other potential economic impacts of urban design such as employment, establishment growth, sales tax receipts, or sales volume (NYCDOT 2013; Hass-Klau 1993). As regards the benefits of urban design to businesses, prior studies have hypothesized that compact, walkable urban environments with a diversity of people and businesses facilitate pedestrian activity to create “effective economic pools of use” (Jacobs, 1961, p. 171). This refers to increased foot traffic and window shopping that is beneficial to businesses in the increased patronization of stores, restaurants and cafes. It has also been hypothesized that urban design practices that emphasize walkable urban forms are likely to attract members of the creative class who prefer walkable, mixed use urban spaces to minimize commute times between work and leisure activities (Florida, 2002). Mixed use, walkable environments are also likely beneficial to businesses that employ working-class employees with more limited transportation and employment choices. Unfortunately, there is virtually no information about the link between businesses (which represent one aspect of urban activity) and good urban design.

To address this research need, the goal of this study is to analyze the linkages between built environment aspects of urban design with business performance, as measured by sales volume per employee. Specifically, hierarchical linear models (HLM) are estimated to analyze neighborhood scale features of the built environment (BE) – as characterized by Jacobs' "four generators of diversity" – and their relationship to business performance. The overarching hypothesis of this study is that the same BE characteristics that promote pedestrian activity will also positively impact business performance. From a theoretical perspective, this is an important yet unassessed dimension of the economic value of good urban design to communities. From a practical perspective, an evaluation of this benefit to urban design will provide important information to planners and economic development practitioners that can enhance their efforts to design economically vibrant places with aesthetic appeal and a sense of place.

The analysis shows that certain features of walkable built environments are positively associated with business performance. However, the relationship between walkable built environments and business performance varies considerably depending on the type of business and city-level context being studied, indicating that significant nuance must be used when considering place-based interventions. Although no causal statements can be made about the built environment and business performance, the results of this paper indicate that (in some contexts) design-based place-making initiatives could be used to generate sustainable local economic development. This provides a welcome alternative to investing in the risky zero-sum game of inter-urban competition for branch plant relocation using traditional economic incentives.

Perspectives on Good Urban Design

Classic theories of urban design emphasize the importance of features including imageability, mixed land uses, short block length, spatial continuity, and human-scaled design (Jacobs 1961; Levy 1999; Moughtin et al. 2003). In recent years, urban design initiatives based on smart growth and new urbanist principles are focused on revitalizing central city and inner ring suburbs to counteract the outward march of people and businesses to the suburbs (Burchell, Listokin, and Galley, 2000; Addison, Zhang, and Coomes, 2013). Urban design principles to achieve smart growth include: mixed used, walkable neighborhoods, a variety of housing types (multi and single family), and a diverse choice set of transportation options (Ye, Mandpe, and Meyer, 2005; Addison, Zhang, and Coomes, 2013). A related but distinct perspective on urban design is the new urbanism. In the charter of the Congress for the New Urbanism (2015), several elements of this design strategy are listed, including: distinctly defined walkable neighborhoods, a connected street network that is lined with buildings, a mix of activities and housing choices, placement of civic places in important areas, amongst others. Given the popularity of these design movements, researchers have attempted to operationalize these ideas for empirical study (Vale et al. 2016). In a widely-cited paper, Cervero and Kockelmanelman (1997) introduced the "Three D's" – density, land use diversity, and street network design – to which the "D's" distance to transit and destination accessibility were later added (Ewing and Cervero, 2010). Similarly, Krizek's (2003b) individual neighborhood accessibility indicators provide a useful encapsulation of the generally-accepted principles of walkable urban design that includes high density, small lots, mixed land use, and access to parks, to name just a few.

Benefits of walkable urban design

Evaluations of good urban design have uncovered a range of social, environmental, and health benefits. Since the 1972 Appleyard and Lintell study of livable streets, which called attention to the role of design in improving neighborhood interactions (Lund, 2003), planners have noted the link between social benefits and good urban design (Montgomery, 1998; Knox, 2005). In fact, a fundamental tenet of the new urbanism is to restore lost neighborhood interactions created by suburbanization and the advent of gated communities by creating a sense of community through the strategic placement of public spaces (Talen, 1999). Aside from facilitating neighborhood scale interactions, good design practice also creates third places outside of home and work such as coffee shops, restaurants, and parks which facilitate casual encounters (Knox, 2005).

Given the health hazards of car-oriented, sedentary, suburban lifestyles (Saelens et al., 2003), the last decade has also witnessed a surge in interest in evaluating the impact of urban design on physical activity (Frank and Engelke, 2001, Saelens et al. 2003). The overarching idea is that good urban design that enhances walkability, will reduce automobile dependence and car-related travel. While early work found little evidence to link design to travel behavior (Crane and Crepeau, 1998; Crane, 2000), a number of studies have uncovered an association between various facets of urban design and travel behavior. Cervero and Kockelman (1997) found modest impacts of built environment characteristics (density, land-use diversity, and pedestrian-oriented design) on travel demand, which lends support for new urbanist design principles. Krizek (2003a) found that locating in neighborhoods with higher levels of accessibility decreased car travel, as measured by vehicle miles traveled. Frank et al (2006) found that people living in walkable neighborhoods with better urban design were more active, less car dependent, and less polluting than residents of less-walkable neighborhoods.

Economic value of walkable urban design

Recent work has also begun to examine the economic benefits of good urban design with a focus on property values. Song and Knaap (2003) found for example that people are willing to pay more for a range of new urbanist neighborhood characteristics such as mixed use, smaller blocks, more connected streets, and proximity to light rail stations. A follow-up study found that a mix of land uses had a positive impact on property values, but that this relationship depended on the mix of land uses considered because multi-family land uses did not positively impact property values (Song and Knaap, 2004). These findings are tempered however by work which finds that walkable amenities do not increase property values in auto-centric neighborhoods (Li et al. 2015). Findings from property value work are also tempered by studies highlighting equity issues with design-specific features of environments that promote walkability (Davis, 1984). This calls into question the widespread affordability of walkable neighborhoods (USDOT, 2008; Pollack et al., 2010) and the economic accessibility of neighborhoods that personify features of good urban design.

Conceptual Framework

While equity issues and gentrification are negative externalities of good urban design, the majority of studies highlight a wide range of social, environmental, and health benefits. Work on the link between design and vibrant cities highlights the importance of a mix of business sizes and types to city vitality (Montgomery, 1998). Figure 1 presents a conceptual framework for thinking about place-making and urban vitality that combines different perspectives on place (psychological, activity-based, and design-based) to highlight how these components interact to create a unique sense of place for urban environments (Montgomery, 1998 p. 98). This figure underscores the fact that there is a reciprocal relationship between local economic activity and place-making. A mix of successful businesses drives urban activity and street life, which constitutes a critical component for creating unique urban places (Montgomery, 1998). And, at the same time, the form and image of urban areas influences business success.

Table 1 provides a more detailed description of each of the three elements of place as outlined by Montgomery (1998). Successful business activity underscores many of these activities: restaurants and coffee shops form the foundation of a café culture and make up the transactions component of fine-grained neighborhood economies. Elements of urban form – such as scale, block length, and diverse building stock – create the underlying conditions for economic activity, and thus design dictates a lot about how that activity plays out. In vital urban places, with a mix of businesses competing, innovating, and vying for customers, we would expect business performance to increase - certainly for those businesses that rely on foot traffic and the public or semi-public realm, such as pubs, cafes, restaurants, and retail shops. The impact of image, legibility, sensory experience, and symbolism on business performance also cannot be ignored. Places with strongly shared memories for a large number of people and easy psychological accessibility should also perform better than nondescript, hard-to-remember areas. This relationship helps to explain the use of nostalgia and place-experience in businesses marketing and advertising, even in "controlled" environments like shopping malls or theme parks (Harvey 1989; Relph, 1976; Venturi et al., 1972).

The interaction of people and businesses, which is enabled by a well-constituted urban design, is a core component of place-making. In addition, a unique place-based identity – nurtured physically by specific urban design components – contributes to individual business success and urban vitality. While "place" is mutually-constituted through the links between form, activity, and image, this paper chooses to focus on a particular relationship - the connection between features of urban form that enhance walkability and business performance. At the most practical level, this is an important link to study, because planners and cities have a relatively high amount of control over the built environment, and profits are the key economic need for a business to survive and be successful (and thus being able to continue to contribute to the realm of urban activity).

Study Area

To analyze the linkages between specific elements of the built environment and business performance, as measured by sales volume per employee, this paper investigates this relationship in two cities with different historical backgrounds, business characteristics, and urban morphologies. Phoenix is a relatively younger, polycentric Sun Belt city that exemplifies the post-WWII suburban-style development patterns; between 1950 and 1990 Phoenix grew from 17 to 420 square miles (Fink, 1993). Issues prompted by sprawl make this metropolitan area a well-studied case of various maladies associated with unmitigated urban expansion (Heim, 2001; Bernstein et al., 2014). After decades of struggle to revitalize a downtown area resembling more a Western ghost town, the downtown core of Phoenix may be on the verge of revitalization (Pela, 2015).

Boston, in contrast, is one of the most historic places in the United States. Its dense historic core dates back to the 1600s and is recognized as a key player in the Revolutionary War. The bustling downtown core of the city is known for its maze of twisted streets in the North end, as well as several renowned institutions of higher education including Boston College, Harvard, and the Massachusetts Institute of Technology (MIT). While Boston, like many major cities, bulldozed blighted areas of the city in urban renewal efforts that displaced thousands of low income families, the city has ongoing urban renewal efforts with increased emphasis on citizen participation and education (Mao, 2015). Recent efforts to strategically guide Boston's growth via Imagine Boston 2030, are a response to the rapid population growth of the metropolitan area in recent years (6% between 2010 and 2014) (Imagine Boston, 2016).

Data

Given the differences between Boston and Phoenix, it is hypothesized that the built environment is positively related to business performance, but that the strength and direction of this association varies across cities due to differences in regional form, behavioral patterns, and economic structure. In this study, the built environment is operationalized with six variables: a density activity score, block length, transit accessibility, pedestrian and bike accessibility, mixed land use, and a diversity of building ages (Jacobs, 1961; Ewing and Cervero, 2010). To test this hypothesis, secondary data were compiled from a variety of sources. These data are summarized in Table 2 and explained in further detail below.

Business data

Point-level data about business location and business performance and productivity, as measured by sales volume per employee, were obtained from two sources, the National Establishment Time Series (NETS) database and the ESRI/Reference USA database. NETS is built in collaboration with Dun and Bradstreet to collect a longitudinal database of business activity that may be tracked over time (Neumark, Wall and Zhang, 2005). Sales information in this database are taken from reported sales at the firm level (Walls and Associates, 2013). Since individual establishments (which make up firms) also report sales, this is how information is obtained for the majority of establishments (Walls and Associates, 2013). In instances where sales are unavailable, estimates of sales per employees and employment information at the establishment level, are used to estimate establishment sales (Walls and Associates, 2013).

The 2010 ESRI Business Analyst data used in this paper also comes from the Dun and Bradstreet database (ESRI, 2014). The primary difference between ESRI Business Analyst and NETS is the extraction and geocoding process; for the former, it is conducted by ESRI, and for the latter, by Don Walls and Associates. The core source – Dun and Bradstreet – for the business information is the same. Only businesses with positive sales volume and at least two employees in 2010 were included in the final dataset. In order to test for industry-specific effects in the relationship between BE features and business performance, dummy variables were constructed for three types of businesses: retail (NAICS 44-45), manufacturing (NAICS 31-33), and knowledge (NAICS 51-52 and 54-55).

Tract-level data

In addition to business-level data on the location, sales volume per employee, and industry type of individual businesses, this paper also employs a unique Census tract database for Boston and Phoenix. Built environment variables were chosen to closely match Jacobs' four generators of diversity (1961), as well as Ewing and Cervero's "5-D's" (2010). Parcel-level data from the Maricopa Association of Governments (MAG) in Phoenix and the City of Boston were used to create a dummy variable for mixed use tracts. This variable was constructed by calculating the percentage of parcels classified as "commercial", "residential," and "public" in each tract; those tracts with at least 5% of both commercial and residential land use, in addition to any percentage of public land use, were classified as "mixed use"[1]. This measure operationalizes the concepts of destination accessibility (Ewing and Cervero, 2010) and the need to have more than one primary use in a district (Jacobs, 1961); 5% represents a minimum percentage of land use in a tract that might realistically contribute to its usage pattern. In order to measure the density of activity in a tract, data about the residential population from the 2010 Decennial Census and employment from the ESRI Business Analyst and NETS business point data were added together and divided by the size of the tract (in acres). This variable provides a total measure of aggregate density in an area that combines the economic benefits of two different kinds of activity modes: daytime (employment) and nighttime/weekend (residents). This is important to capture since activity from residents and workers at different times of day – even if they happen to be the same individual human being – is essential to fostering vibrant places (Jacobs, 1961). The intention of using this kind of density activity score, rather than employment or population density alone, is to create a measure that captures the economic benefits of tracts in which a large amount of people both work and live. These are the dense kinds of areas that provide 24-hour street life and value to businesses of all types.

Block length is another important characteristic of street network design – this measure was obtained by calculating the perimeter of each tract's nested 2010 Census blocks (which generally correspond to a city block) and averaging those values across tracts. The Census also provides data on building age by tract – the share of total buildings by decade (from pre-1939 through post-2010). These data were used to create a Herfindahl Index of building age that captures

[1] Based on the land use categories obtained from the parcel data, "commercial" land uses were those coded C1 (small-scale retail), C2 (restaurants, coffee shops, bakeries, etc.), C3 (office buildings and banks), MU2 (vertical mixed use without residential), and S1 (commercial services, e.g., dry cleaning). "Residential" land uses included in the calculation of the mixed use dummy were MU1 (vertical mixed use with residential), R2 (single-family attached housing), and R3 (condominiums and multi-family housing). "Public" uses were PO1 (plaza, parks, playgrounds, etc.) and S3 (public recreational buildings, libraries, etc.). In Phoenix, 12 of 357 tracts were classified as mixed use, while in Boston, 18 of 176 met the definition.

the diversity of business ages and types within neighborhoods (Jacobs, 1961). Finally, transit and pedestrian/bike accessibility, which are important dimensions of walkable design (Ewing and Cervero, 2010), were estimated by calculating the share of transit commuters and pedestrian/bike commuters (respectively) by tract from the 2008-2012 American Community Survey (ACS).

In addition to these BE variables, demographic and spatial control variables were also included in the study. Demographic data were collected from the 2008-2012 ACS about median age, the share of population with a Bachelor's degree or higher, and the ethnic/racial profile of the population. The race/ethnicity variables include: the percentage of white non-Hispanic, black non-Hispanic, Asian non-Hispanic, and Hispanic population per tract. A series of spatially lagged variables were also created in order to control for spatial autocorrelation.

Given the need to include controls for spatial effects in this modeling framework, this study models spatial effects through the independent variables. This enables the use of a first-order queen weights matrix and also exploits little-used information about the way spatial models are estimated. When spatial lag models are estimated, lags of each of the independent variables are produced (Anselin, 1988). This is because regression models produce estimates of the dependent variable as a function of the independent variables. Thus, by lagging key independent variables that are responsible for spatial effects in the dependent variable, it is possible to indirectly account for the bulk of spatial dependence in the dependent variable.

In order to determine which independent variables had strong relationships with the spatial distribution of the dependent variable (and thus were good candidates to lag), the local Moran's I was calculated for the average sales volume per employee (aggregated dependent variable at Level-2), as well as each independent variable, in both study areas. The independent variables lagged were those with the highest correlation of local Moran's I 'hot spots' to those of the average sales volume per employee (by tract). In Phoenix, lags were computed for median age, white non-Hispanic, and Bachelor's degree attainment variables, while in Boston, transit accessibility and density activity score were lagged.

Methodology

This paper uses two-level hierarchical linear modeling to examine the relationship between individual- and neighborhood-level traits and the sales volume of individual businesses (Raudenbush and Bryk 2002). In this case, the Level-1 units (individual businesses) are nested within Level-2 units (neighborhoods, operationalized as Census tracts). Conceptually, HLM is similar to estimating a pooled ordinary least squares (OLS) model for all of the individuals within Level-1, where the dependent variable is a characteristic of the individuals (in this case, it is individual establishment sales volume per employee in 2010). In the "random coefficients" model, the intercept and each of the slope coefficients for the Level-1 equation become the dependent variables for a new set of regression equations, with Level-2 independent variables (e.g., average block length, mixed use dummy, density activity score, etc.) and coefficients included in each (Woltman et al. 2012). The "intercepts- and slopes-as outcomes" or "random slopes" model expands on the random coefficient model by including Level-2 variables to predict the slope of each Level-1 predictor (Raudenbush and Bryk 2002). In the context of understanding the relationship between the BE characteristics of tracts and business performance, this modeling approach provides detailed information about the association between tract characteristics and individual business determinants of sales performance, including (importantly) industry type. In order to estimate an effective random slopes model to answer the research question of interest, it is necessary to estimate preceding models which provide important information about the variation in sales performance and proposed individual and tract determinants of performance.

Null model

The first step in HLM model-building is to estimate a “null model” to which additional variables can be added (Hox 2002). The Level-1 and Level-2 equations for the HLM null model used in this paper are given by (Raudenbush and Bryk 2002):

$$LOGSALES_{ij} = \beta_{0j} + r_{ij} \qquad (1)$$

$$\beta_{0j} = \gamma_{00} + u_{0j} \qquad (2)$$

where $LOGSALES_{ij}$ is the natural logarithm of the sales volume per employee for the i^{th} establishment in the j^{th} tract, r_{ij} is the random Level-1 residual, β_{0j} is the random intercept for tract *j*, γ_{00} is the grand mean’s Level-2 intercept (which is estimated as a weighted average of tract means), and u_{0j} is the random Level-2 residual or the dispersion around the grand/overall mean. Taken together, the final equation for the null model is:

$$LOGSALES_{ij} = \gamma_{00} + u_{0j} + r_{ij} \qquad (3)$$

This model is important because it provides information about the nature of the variation in sales volume that occurs between tracts (τ_{00}) as a proportion of total variability – both between and within tracts (σ^2) . This information may be summarized with the intraclass correlation coefficient (ρ) in equation 4 (Raudenbush and Bryk 2002; Woltman et al. 2012):

$$. \rho = \frac{\tau_{00}}{\tau_{00}+\sigma^2} \qquad (4)$$

Larger values of this coefficient highlight more variation in sales volume driven by tract characteristics rather than individual business characteristics. This means that the intraclass correlation coefficient demonstrates the relative importance of neighborhood factors vs. characteristics of the individual businesses themselves in predicting sales volume. While we might expect that specific features of businesses are the most important factor in explaining sales performance (including some unobservable characteristics), the degree to which neighborhood grouping matters provides insight into the role of neighborhood context in the distribution of sales volume per employee, and addresses the first research question of interest. Table 3 presents the results of the intraclass correlation coefficients for Phoenix and Boston and highlights that neighborhood characteristics account for a higher proportion of variation in sales volume per employee in Phoenix (5.3%) than in Boston (3%).

Random Coefficients Model

Building on these findings, the next step in the analysis is to build a random coefficients model with relevant covariates for each metropolitan area. The specification of the mixed random coefficients model for Phoenix is:

$$LOGSALES_{ij} = \gamma_{00} + \gamma_{01}BLKNH_j + \gamma_{02}ASNNH_j + \gamma_{03}TRANS_j + \gamma_{04}DENSITY_j + \gamma_{05}AVG\_SHAP_j + \gamma_{06}B\_AGE\_HI_j + \gamma_{07}PEDB_j + \gamma_{10}RETAIL_{ij} + \gamma_{20}MAN_{ij} + \gamma_{30}KNOW_{ij} + u_{0j} + u_{1j}RETAIL_{ij} + u_{2j}MAN_{ij} + u_{3j}KNOW_{ij} + r_{ij} \quad (5)$$

The random coefficients specification for Boston is:

$$LOGSALES_{ij} = \gamma_{00} + \gamma_{01}TRANS_j + \gamma_{02}DENSITY_j + \gamma_{03}B\_AGE\_HI_j + \gamma_{04}MIX_j + \gamma_{05}TRANSLAG_j + \gamma_{10}RETAIL_{ij} + \gamma_{20}MAN_{ij} + \gamma_{30}KNOW_{ij} + u_{0j} + u_{1j}RETAIL_{ij} + u_{2j}MAN_{ij} + u_{3j}KNOW_{ij} + r_{ij} \quad (6)$$

In the construction of these models, it is critical to assess statistical issues such as confounding variables and collinearity (Hox 2002; Clark 2013; Yu, Jiang, and Land 2015). In order to assess the impact of collinearity, variance inflation factors (VIF) were calculated for each of the covariates of interest (separately) in both Phoenix and Boston. The results of these calculations are shown in Appendix A. VIF > 5 are generally considered to be problematic (Clark 2013; Yu, Jiang, and Land 2015); so variables in each region with VIF above 5 were removed (shown in bold in Appendix A). Additional confounding variables – discovered when running the random coefficients models in cases where coefficients displayed the opposite sign of the underlying variable's correlation with the dependent variable – are also identified in Appendix A, and were removed from the final model specification. In both cities, many of the demographic variables are correlated, which explains why these characteristics could not be included in the final models, and also provides insight into the relatively-segregated nature of neighborhoods in both cities. In Boston, for example, the black non-Hispanic population is highly negatively correlated with both white non-Hispanic population (-.83) and Bachelor's degree attainment (-.66), while the Hispanic population is positively correlated with transit commuting (.55) and negatively correlated with Bachelor's degree attainment (-.57). In Phoenix, the white non-Hispanic population is negatively correlated with Hispanic population (-.90) and positively correlated with median age (.80) and Bachelor's degree attainment (.76).

In equations 5 and 6, all variables are grand mean centered. Due to the importance of the intercept in HLM models, centering is often recommended, even for Level-1 dummy variables (Raudenbush and Bryk 2002, p. 34). If a predictor – for example, *TRANS* – remains un-centered, the intercept found by the equation is the expected sales volume per employee for a business in tract *j* with 0% transit commuting percentage. It is more useful (for the purposes of this paper) to set the intercept equal to the expected sales volume per employee for a business in tract *j* whose transit commuting percentage is equal to the *average* transit commuting percentage in the study area (grand mean). Thus, all of the independent and dependent variables in this paper are grand mean-centered.

Random Slopes Model

While the random coefficients model shows which BE factors positively relate to business performance, while controlling for industry effects, estimating a random slopes model is necessary in order to find which BE factors positively correspond to the performance of specific types of businesses. This model is an extension of the random coefficients model, with Level-2 predictors added to explain the slope coefficients of each of the Level-1 predictors, creating several cross-level interaction terms. For Phoenix, the mixed random slopes model specification is:

$$LOGSALES_{ij} = \gamma_{00} + \gamma_{01}BLKNH_j + \gamma_{02}ASNNH_j + \gamma_{03}TRANS_j + \gamma_{04}DENSITY_j + \gamma_{05}AVG\_SHAP_j + \gamma_{06}B\_AGE\_HI_j + \gamma_{07}PEDB_j + \gamma_{10}RETAIL_{ij} + \gamma_{11}TRANS * RETAIL_{ij} + \gamma_{12}DENSITY * RETAIL_{ij} + \gamma_{13}AVG\_SHAP * RETAIL_{ij} + \gamma_{14}B\_AGE\_HI * RETAIL_{ij} + \gamma_{15}PEDB * RETAIL_{ij} + \gamma_{20}KNOW_{ij} + \gamma_{21}TRANS * KNOW_{ij} + \gamma_{22}DENSITY * KNOW_{ij} + \gamma_{23}AVG\_SHAPE * KNOW_{ij} + \gamma_{24}B\_AGE\_HI * KNOW_{ij} + \gamma_{25}PEDB * KNOW_{ij} + \gamma_{30}MAN_{ij} + \gamma_{31}TRANS * MAN_{ij} + \gamma_{32}DENSITY * MAN_{ij} + \gamma_{33}AVG\_SHAPE * MAN_{ij} + \gamma_{34}B\_AGE\_HI * MAN_{ij} + \gamma_{35}PEDB * MAN_{ij} + u_{0j} + u_{1j}RETAIL_{ij} + u_{2j}KNOW_{ij} + u_{3j}MAN_{ij} + r_{ij} \tag{7}$$

The random slopes specification for Boston[2] is:

$$LOGSALES_{ij} = \gamma_{00} + \gamma_{01}TRANS_j + \gamma_{02}DENSITY_j + \gamma_{03}B\_AGE\_HI_j + \gamma_{04}MIX_j + \gamma_{05}TRANSLAG_j + \gamma_{10}RETAIL_{ij} + \gamma_{11}TRANS * RETAIL_{ij} + \gamma_{12}DENSITY * RETAIL_{ij} + \gamma_{13}B\_AGE\_HI * RETAIL_{ij} + \gamma_{14}MIX * RETAIL_{ij} + \gamma_{20}KNOW_{ij} + \gamma_{21}TRANS * KNOW_{ij} + \gamma_{22}DENSITY * KNOW_{ij} + \gamma_{23}B\_AGE\_HI * KNOW_{ij} + \gamma_{24}MIX * KNOW_{ij} + u_{0j} + u_{1j}RETAIL_{ij} + u_{2j}KNOW_{ij} + r_{ij} \tag{8}$$

[2] As shown below, *MAN* was removed from this specification due to a lack of significant variability remaining from the random coefficients model.

Results

Prior to describing these model results, it is necessary to highlight some important differences between the two metropolitan areas which are critical to understanding the results. Appendix A displays the descriptive statistics for each of the variables considered in the HLM models described above. In terms of industry breakdown, 17% of the businesses in Phoenix are classified as retail; 6% are manufacturing, and 19% are related to knowledge-based work. In Boston, the breakdown is 9% retail, 2% manufacturing, and 27% knowledge. Nearly all of the characteristics associated with the chosen variables of walkable built environments are found in higher average quantities in Boston than in Phoenix, including density activity score (55 residents and employees per acre vs. 11), mixed use tract percentage (10% to 3%), shorter average block length (1,986 meters to 3,773 meters), transit commuting percentage (32% to 4%), and pedestrian/bike commuting percentage (16% to 3%). Rates of building age diversity within tracts are actually higher in Phoenix, with a slightly lower Herfindahl Index value of 0.37 vs. Boston's 0.41. Since low values of the Herfindahl index correspond to industrially diverse economies, these numbers mean that both Phoenix and Boston have relatively diverse industrial mixes. In terms of demographic indicators, Boston's median age is 35.9, compared to Phoenix's 33.2. As for educational attainment, 43% of people in Boston have a bachelor's degree or higher, compared to 25% in Phoenix. The racial/ethnic mix of people is also distinct between the two metropolitan areas. Boston has comparatively more Black and Asian residents while Phoenix has more Hispanic residents (39% compared to 17%).

Boston also has higher average sales volume per employee ($68,186) than Phoenix ($159)[3].

[3] While this is a seemingly large gap, there are several possible explanations based on the significant differences in the economies of Boston and Phoenix. The overall patterns of urban development are quite different in Boston than

Figure 2 shows the results of a local Moran's I analysis of average sales volume between the two study areas. In Phoenix, the highest concentrations of sales volume are found in downtown Phoenix and along a stretch south of downtown that includes Sky Harbor Airport and industrial areas along the Salt River. This area of central Phoenix also contains most of the 'hot spots' of local spatial autocorrelation of average sales volume per employee (those tracts classified as significantly "high high" and "high low" using a local Moran's I analysis) (Anselin 1995). The high-high category includes tracts with higher than average sales volumes that are surrounded by tracts with similarly high sales volumes. The high-low category contains tracts that have higher than average sales volumes but are surrounded by tracts with lower than average sales volumes. The I-17 corridor – home to several large research and technology parks (Metro Research Center, Cave Creek Industrial Center, Karsten Industrial Complex, Eaton Industrial, and the Black Canyon Commerce Park) and the Metrocenter Mall – also shows concentrations of higher average sales volumes per employee. Newly-developed areas in north Phoenix, such as Desert View and Deer Valley, also contain higher concentrations of average sales volume per employee.

In Boston, Charlestown (north of the Charles River, near Cambridge) is a hot spot of high sales volume per employee. The area around Logan International Airport, the West End, South Boston (including the neighborhood surrounding the Boston Innovation District), and the Jamaica Plain neighborhood also show higher average sales volumes per employee. Overall, average sales volumes per employee are much higher in Boston than in Phoenix.

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in Phoenix – as a denser, more urban city with significantly higher property values, it is likely that businesses in Boston need to obtain higher sales volumes in order to offset high operating expenses (including land, labor, and capital). The spending power of residents in each city is also different – according to the 2008-2012 American Community Survey, average household income in Boston was $53,136, while in Phoenix it was $47,866. In addition, the fact that this data represents a cross-section of sales for 2010 could play a role in the difference – since this is directly after the Great Recession, it is possible that there are regional differences in the ways in which these industries were negatively impacted and/or able to recover.

Model results

While the descriptive statistics and maps provide some insight into the spatial relationship between sales volume and neighborhood features, the model results provide detailed information about the strength of the statistical relationships between these variables. Table 4 shows the results of the random coefficients models specified in equations (5) and (6) with the random slopes models specified in equations (7) and (8). While this table does not report coefficient values, it does indicate important findings for the HLM model-building process and industry-specific effects. In Phoenix, all of the Level-1 variables have a significant p-value (<0.001), showing that significant variance in the relationship between these variables and individual business performance remains *unexplained* in the random coefficients model. For Boston, however, the *MAN* variable displays a highly-insignificant value (>0.500), meaning that its variance has been sufficiently explained by the random coefficients model and thus should be removed from additional model specifications (i.e., there is nothing significant remaining to explain by adding covariates to better specify its slope) (Raudenbush and Bryk 2002).

Table 4 also indicates the proportion of additional variance explained by the random slopes model (and thus serves as justification for its use). In a similar way to the intraclass correlation coefficient, this proportion is calculated by subtracting the "conditional" variance explained by the random slopes model from the "unconditional" variance specified by the random coefficients model, and dividing that by the unconditional variance (Woltman et al. 2012; Raudenbush and Bryk 2002):

$$Proportion\ variation\ explained\ in\ \beta_q = \frac{\hat{\tau}_{qq}(unconditional) - \hat{\tau}_{qq}(conditional)}{\hat{\tau}_{qq}(unconditional)} \quad (9)$$

The resulting value – shown in the last column of Table 4 – indicates how much additional variance the random slopes models specified in equations (7) and (8) explain. And, since only Level-2 BE variables were added to explain the Level-1 industry characteristics in these models, this value also indicates how much additional variance in sales volume per employee these BE variables explain for each type of business. In Phoenix, BE variables explain only 1.8% and 1.4% of the performance of retail and manufacturing establishments (respectively), but add 8.3% to the description of knowledge business performance. Thus, in Phoenix, the results show that BE variables are more important to knowledge business performance than retail or manufacturing performance. In Boston, 35% of the performance of retail businesses and 22% of the performance of knowledge businesses is explained by the addition of BE predictors in the random slopes model, indicating that these variables play an important role in explaining the performance of these types of businesses.

To understand the relationship between BE characteristics and business performance in specific industries, Table 5 displays model results for the random slopes models for Phoenix and Boston. In Phoenix, model results indicate that businesses outside of the retail, manufacturing, and knowledge sectors that are located in tracts with higher percentages of black non-Hispanic population and transit commuting have better performance. Tracts with lower density activity scores, longer average block length, and a larger diversity of building ages are also positively associated with better business performance. For retail businesses in particular, the built environment has no relationship with performance. For the manufacturing and knowledge sectors, various features of the built environment are related with business performance. These features include: higher density activity score, lower transit commuting percentage, and less building age diversity.

In Boston, Table 5 highlights that higher performance for manufacturing and knowledge businesses is significantly related to lower transit commuting percentage and location in a mixed use neighborhood. On the other hand, higher sales volume per employee for retail businesses corresponds to higher transit commuting percentage, lower density activity score, a diversity of building ages, and location in neighborhoods largely dominated by a single use. None of the individual BE variables are significant predictors of knowledge business performance.

Discussion and Conclusion

The goal of this study is to analyze the linkages between good urban design and individual business performance, as measured by sales volume per employee. Results of the hierarchical linear models estimated reveal that the relationship between the performance of individual businesses and the built environment features of the neighborhoods in which they are located is complex, nuanced, and highly-dependent on the type of business and city in question. In Phoenix, for example, BE characteristics were important to understanding the performance of knowledge but not retail or manufacturing businesses; in Boston, BE characteristics were important to understanding the performance of both knowledge and retail businesses. While there are certainly interesting details to be gleaned from the results, the overarching finding is that there is no 'one-size-fits-all' approach to place-based economic development. Neighborhood-level features play an important role in explaining the variation in business performance in both Phoenix and Boston; while it is clear that business performance and productivity is largely a product of features endemic to individual businesses (such as management, financial status, technology, market demand for the product, location in a specialized business cluster, etc.), a consequential portion *is* related to characteristics of the local neighborhood, such as demographics and the built environment.

Table 6 summarizes the results for the two metropolitan areas and highlights that several walkable BE components are significantly related to higher business performance. In Phoenix, businesses in tracts with higher levels of transit commuting and building age diversity – as measured by a Herfindahl Index of the shares of buildings constructed in different decades (from 1939 – present) – have higher sales volumes per employee, while in Boston, the same is true for businesses located in mixed use tracts, even when controlling for socio-demographic features of the neighborhood and the characteristics of specific business types. This provides some evidence supporting Jacobs' assertion that visual intricacy and a variety of flexible building space helps foster economic activity (1961).

At the same time, this analysis shows that some elements of walkable built environments are negatively related to business performance. In Phoenix, lower densities and longer average block length are connected with higher performance, which suggests that in some cases auto-centric built environments lead to better business outcomes; this is particularly true in a city like Phoenix, where auto-centric urban form – and economic behavior – is prevalent. Businesses that require a lot of parking to support their business model, such as big-box retail stores, do not substantially benefit from walkable urban design, which could be driving an insignificant result for the retail variable in Phoenix. This underscores the fact that, while measured in the same way, the walkable built environment variables tested here mean different things in different urban contexts, e.g., transit use is a different economic indicator in Boston than it is in Phoenix.

Certainly, this paper represents the beginning of an analysis of the neighborhood-level micro-foundations of business performance, and future work is needed to illuminate specific relationships in a wider range of contexts. Larger nested models with a variety of regional types could shed light on the ways in which metropolitan-level features influence place-making and business performance. For that to be possible, however, a large sample of individual businesses – perhaps drawn from several years – would be necessary in order to ensure a sufficient amount of within-tract variation. Another interesting extension of this paper would be to provide a more precise breakdown of the interaction effects of various BE features – one of the limitations of this work is that, especially in Boston, several of the design characteristics are too collinear to use together in a regression. Principle Components Analysis (PCA) could perhaps be used to better understand the relationship that these variables have to one another. Similar approaches could also be used to test Jacobs' assertion that the features of urban design function properly only when they are all concurrently present – that the whole is greater than the sum of its parts, so to speak (1961).

Despite these limitations, the findings indicate that physical design interventions such as historic preservation (to maintain a diverse building stock) and the development of fine-grained mixed use places have the potential to increase the performance of individual businesses. These results suggest economic benefits to urban design above and beyond the social, health, and environmental benefits of walkable urban environments noted in previous studies. However, policy interventions must be context-dependent and sensitive to a locality's economic structure, aggregate urban form, and behavioral patterns. The results of this paper suggest that walkable built environments have different – sometimes even negative – relationships with business performance in different urban contexts. Planning efforts to design economically vibrant places with aesthetic appeal and a sense of place *can* be used by economic developers to market profitable place characteristics to prospective businesses, but practitioners must be careful to understand that effects for different types of businesses, customers, and markets will vary. Economic development strategies based around place-making initiatives should be targeted to the specific businesses that will benefit most from specific built environment features; this study represents the first step in understanding these detailed relationships.

References

Addison, C., Zhang, S., & Coomes, B. (2013). Smart growth and housing affordability: A review of regulatory mechanisms and planning practices. *Journal of Planning Literature, 28*(3), 215-257.

Anselin, Luc. 1988. *Spatial econometrics: methods and models.* Dordrecht: Kluwer Academic Publishers.

Anselin, L. 1995. "Local Indicators of Spatial Association–LISA." Geographical Analysis 27(2): 93-115.

Appleyard, D., & Lintell, M. (1972). The environmental quality of city streets: the residents' viewpoint. *Journal of the American Institute of Planners, 38*(2), 84-101.

Bernstein, M. J., Wiek, A., Brundiers, K., Pearson, K., Minowitz, A., Kay, B., and Golub, A. 2016. Mitigating urban sprawl effects: a collaborative tree and shade intervention in Phoenix, Arizona, USA. *Local Environment*, *21*(4), 414-431.

Burchell, R. W., Listokin, D., & Galley, C. C. (2000). Smart growth: More than a ghost of urban policy past, less than a bold new horizon. *Housing Policy Debate*, *11*(4), 821-879.

Cervero, R., & Kockelman, K. (1997). Travel demand and the 3Ds: Density, diversity, and design. *Transportation Research Part D: Transport and Environment*, *2*(3), 199-219.

Clark, Patrick. 2013. *The effects of multicollinearity in multilevel models*. Dissertation: Wright State University.

Congress of Urbanism (2015). Charter of the New Urbanism. Retrieved from: https://www.cnu.org/who-we-are/charter-new-urbanism. Accessed: January 2016.

Crane, R. (2000). The influence of urban form on travel: An interpretive review. *Journal of Planning Literature*, *15*(1), 3-23.

Crane, R., & Crepeau, R. (1998). Does neighborhood design influence travel? A behavioral analysis of travel diary and GIS data. *Transportation Research Part D: Transport and Environment*, *3*(4), 225-238.

Davis, J.E. (1984). Reallocating Equity: A Land Trust Model of Land Reform. In Charles C. Geisler and Frank J. Popper, Eds. *Land Reform, American Style*. Totowa, NJ: Rowman & Littlefield. Pp. 209-232. Reprinted in 2010 in *The Community Land Trust Reader,* pp. 362-385.

ESRI. 2014. Methodology Statement: 2014 ESRI US Business Locations and Business Summary Data.http://downloads.esri.com/esri_content_doc/dbl/us/J9940_Methodology_Statement_Esri_US_Business_Locations_Business_Su.pdf. Accessed: June 2016.

Ewing, R., & Cervero, R. (2010). Travel and the built environment: A meta-analysis. *Journal of the American Planning Association, 76*(3), 265-294.

Fink, M. (1993). Toward a sunbelt urban design manifesto. *Journal of the American Planning Association*, *59*(3), 320-333.

Florida, R. (2002). *The Rise of the Creative Class: And How It's Transforming Work, Leisure, Community, and Everyday Life*. New York: Basic Books.

Frank, L. D., & Engelke, P. O. (2001). The built environment and human activity patterns: exploring the impacts of urban form on public health. *Journal of Planning Literature*, *16*(2), 202-218.

Frank, L.D., J.F. Sallis, T.L. Conway, J.E. Chapman, B.E. Saelens, and W. Bachman. (2006). Many pathways from land use to health: Associations between neighborhood walkability and active transportation, body mass index, and air quality. *Journal of the American Planning Association* 72(1): 75-87.

Harvey, D. 1989. *The Condition of Postmodernity: An Inquiry into the Origins of Cultural Change*. Cambridge: Wiley-Blackwell.

Hass-Klau, C. (1993). A review of the evidence from Germany and the U.K. *Transport Policy*, *1*(1), 21-31.

Heim, C. E. 2001. Leapfrogging, urban sprawl, and growth management: Phoenix, 1950–2000. *American Journal of Economics and Sociology*, *60*(1), 245-283.

Hox, J. (2002). *Multilevel Analysis Techniques and Applications.* Mahwah, NJ: Lawrence Erlbaum Associates, Publishers.

Imagine Boston. 2016. Imagine Boston 2030. Retrieved from: http://imagine.boston.gov/. Accessed: January 2016.

Jacobs, J. 1961. *The Death and Life of Great American Cities*. New York: Random House.

Knox, P. L. (2005). Creating ordinary places: Slow cities in a fast world. *Journal of Urban Design*, *10*(1), 1-11.

Krizek, K.J. (2003a). Neighborhood services, trip purpose, and tour-based travel. *Transportation* 30: 287-410.

Krizek, K.J. (2003b). Operationalizing neighborhood accessibility for land use-travel behavior research and regional modeling. *Journal of Planning Education and Research* 22(3): 270-287.

Leinberger, C., & Alfonzo, M. (2012). Walk this way: The economic promise of walkable places in metropolitan Washington, DC. *The Brookings Institution*.

Levy, A. (1999). Urban morphology and the problem of the modern urban fabric: some questions for research. *Urban Morphology*, *3(*2*)*, 79-85.

Li, W., K. Joh, C. Lee, J. Kim, H. Park, and A. Woo. (2014). From car-dependent neighborhoods to walkers' paradise: Estimating walkability premiums in the condominium housing market. *Transportation Research Record* 2453: 162-170.

Li, W., Joh, K., Lee, C., Kim, J. H., Park, H., & Woo, A. (2015). Assessing benefits of neighborhood walkability to single-family property values a spatial hedonic study in Austin, Texas. *Journal of Planning Education and Research 35*(4): 471-488.

Lund, H. (2003). Testing the claims of new urbanism: Local access, pedestrian travel, and neighboring behaviors. *Journal of the American Planning Association*, *69*(4), 414-429.

Mao, J. 2015. Boston Designers Want to "Refresh" Urban Renewal. Next City. April 29, 2015. Retrieved from: https://nextcity.org/daily/entry/boston-urban-design-urban-renewal-city-planning-2015-meetings. Accessed: January 2016.

Mayer, H. and P.J. Knox. (2006). Slow cities: sustainable places in a fast world. *Journal of Urban Affairs*, 28(4), 321-334.

Montgomery, J. (1998). Making a city: Urbanity, vitality and urban design. *Journal of Urban Design*, *3*(1), 93-116.

Moughtin, J. C., R. Cuesta, C. Sarris, and P. Signoretta. (2003). *Urban design: Methods and techniques*. Routledge: Burlington, MA.

New York City Department of Transportation (NYCDOT). 2013. “The Economic Benefits of Sustainable Streets.” Retrieved from: http://www.nyc.gov/html/dot/downloads/pdf/2013-dot-sustainable-streets-lowres.pdf. Accessed: March 2016.

Neumark, D., Zhang, J., & Wall, B. (2005). Business establishment dynamics and employment growth. *Hudson Institute Research Paper*, (05-02).

Pela, R. 2015. Roosevelt Row: The Fight to Keep Downtown Phoenix “Authentic” Is a Fight to Let It Become Something It’s Never Been. Phoenix New Times. February 25, 2015. Retrieved from: http://www.phoenixnewtimes.com/arts/roosevelt-row-the-fight-to-keep-downtown-phoenix-authentic-is-a-fight-to-let-it-become-something-its-never-been-6569021. Accessed June 2016.

Pivo, G., & Fisher, J. D. (2011). The walkability premium in commercial real estate investments. *Real Estate Economics*, *39*(2), 185-219.

Pollack, S., B. Bluestone, and C. Billingham. (2010). *Maintaining Diversity in America’s Transit-Rich Neighborhoods: Tools for Equitable Neighborhood Change*. Boston, MA: Dukakis Center for Urban and Regional Policy at Northeastern University.

Raudenbush, S. W., & Bryk, A. S. (2002). *Hierarchical linear models: Applications and data analysis methods* (Vol. 1). Sage.

Relph, E. 1976. *Place and Placelessness*. London: Pion Limited.

Saelens, B. E., Sallis, J. F., Black, J. B., & Chen, D. (2003). Neighborhood-based differences in physical activity: an environment scale evaluation. *American Journal of Public Health*, *93*(9), 1552-1558.

Song, Y., & Knaap, G. J. (2004). Measuring the effects of mixed land uses on housing values. *Regional Science and Urban Economics*, *34*(6), 663-680.

Song, Y., & Knaap, G. J. (2003). New urbanism and housing values: a disaggregate assessment. *Journal of Urban Economics*, *54*(2), 218-238.

Talen, E. (1999). Sense of community and neighbourhood form: An assessment of the social doctrine of new urbanism. *Urban Studies*, *36*(8), 1361-1379.

United States Department of Transportation. 2008. *Realizing the Potential: One Year Later, Housing Opportunities near Transit in a Changing Market.* Washington, D.C.: U.S. Department of Transportation.

Vale, D.S., M. Pereira, and M. Saraiva. (2016). Active accessibility: A review of operational measures of walking and cycling accessibility. *The Journal of Transport and Land Use* 9(1): 1-27.

Venturi, R., D.S. Brown, and S. Izenour. 1972. *Learning from Las Vegas: The Forgotten Symbolism of Architectural Form*. Cambridge: MIT Press.

Walls & Associates (2013). National Establishment Time-Series (NETS) Database: 2012 Database Description. Retrieved from: http://exceptionalgrowth.org/downloads/NETSDatabaseDescription2013.pdf. Accessed: January 2016.

Woltman, H., Feldstain, A., MacKay, J. C., & Rocchi, M. (2012). An introduction to hierarchical linear modeling. *Tutorials in Quantitative Methods for Psychology*, *8*(1), 52-69.

Ye, L., Mandpe, S., & Meyer, P. B. (2005). What is “smart growth?”—Really?. *Journal of Planning Literature*, 19(3), 301-315.

Yu, Han, S. Jiang, and K.C. Land. 2015. "Multicollinearity in hierarchical linear models." *Social Science Research* 53: 118-136.

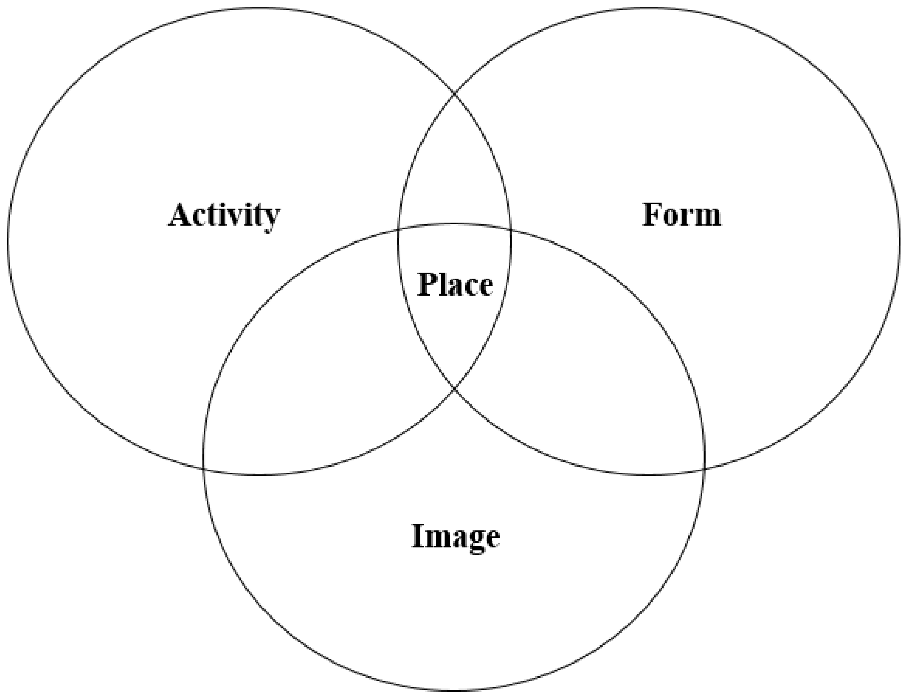
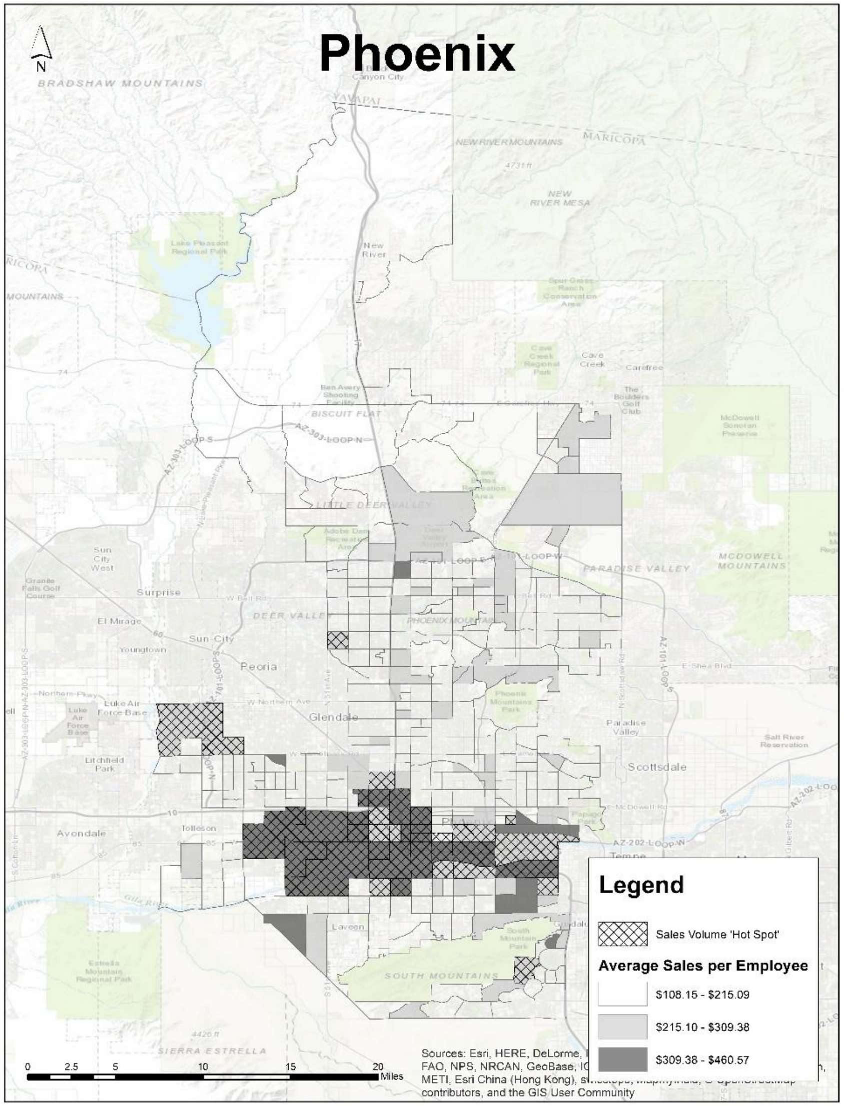


Figure 1. Conceptual framework for components of urban place-making.

Source: Montgomery (1998)



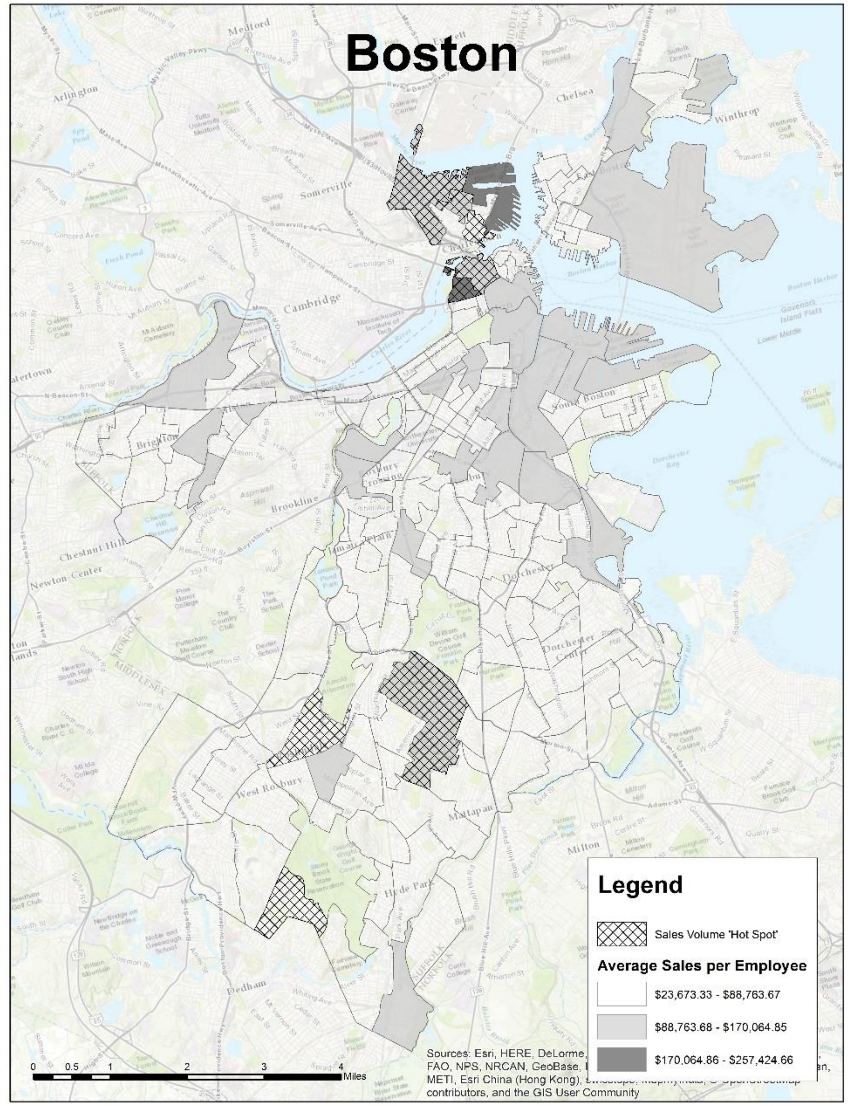


Figure 2. Maps showing spatial 'hot spots' and distribution of average sales volume per employee by tract in Phoenix and Boston.

Table 1. Activity-, form-, and image-based components of place-making.

Components of Place-Making
Street life, diversity, vitality, people-watching, café culture, events and local traditions, transaction base, fine-grain economy
Scale, intensity, permeability, landmarks, diverse building stock, public spaces, space to building ratios, block length
Symbolism and memory, imageability, legibility, sensory experience and associations, receptivity, psychological access, lack of fear

Source: Montgomery (1998).

Table 2. List of variables considered for use in models.

Level	Category	Variable Name	Description	Source
Level-1	*Business characteristics*	LOGSALES	Dependent variable: natural log of sales volume per employee	NETS 2010 & ESRI/Reference USA
		RETAIL	Dummy for retail business (NAICS 44-45)	NETS 2010 & ESRI/Reference USA
		MAN	Dummy for manufacturing business (NAICS 31-33)	NETS 2010 & ESRI/Reference USA
		KNOW	Dummy for knowledge business (NAICS 51-52 and 54-55)	NETS 2010 & ESRI/Reference USA
Level-2	*Demographic variables*	MEDAGE	Population median age	ACS 2008-2012
		WHTNH	% white non-Hispanic population	ACS 2008-2012
		BLKNH	% black non-Hispanic population	ACS 2008-2012
		ASNNH	% Asian non-Hispanic population	ACS 2008-2012
		HISP	% Hispanic population	ACS 2008-2012
		BACH	% population with Bachelor's degree or higher education	ACS 2008-2012
	Features of walkable built environments[1]	TRANS	% commuting to work via transit	ACS 2008-2012
		DENSITY	Population + employees per acre	ACS 2008-2012
		AVG_SHAP	Average Census block perimeter length (in meters) of the tract	ACS 2008-2012
		B_AGE_HI	Herfindahl Index (HI) for building age by decade from 1939-2012	ACS 2008-2012
		MIX	Dummy for mixed use[2]	Parcel-level data from MAG and City of Boston
		PEDB	% commuting to work via walking or biking	ACS 2008-2012
	Spatial lag[3]	TRANSLAG	Spatial lag for TRANS variable	ACS 2008-2012
		POPEDLAG	Spatial lag for DENSITY variable	ACS 2008-2012
		MEDALAG	Spatial lag for MEDAGE variable	ACS 2008-2012
		WHITELAG	Spatial lag for WHTNH variable	ACS 2008-2012
		BACHLAG	Spatial lag for BACH variable	ACS 2008-2012

Note: NETS = National Establishment Time Series; ACS = American Community Survey; MAG = Maricopa Association of Governments.

[1]Variables chosen to match Jacobs' four generators of diversity (1961) and Ewing and Cervero's "5-D's" (2010).

[2]This variable was constructed by calculating the percentage of parcels classified as "commercial", "residential," and "public" in each tract; tracts with ≥ 5% of both commercial and residential land use, in addition to any % of public land use, were classified as "mixed use".

[3]Spatial lag variables use a first-order queen contiguity spatial weights matrix.

Table 3. Intraclass correlation coefficients for Phoenix and Boston.

	Phoenix		Boston	
Random Effect	*Std. Dev.*	*Variance*	*Std. Dev.*	*Variance*
INTRCPT1, u0	0.179	0.032	0.105	0.011
level-1, r	0.758	0.575	0.601	0.362
Intraclass Correlation	**5.3%**		**3.0%**	

Table 4. Additional variance explained by random slopes model for Phoenix and Boston.

		Random Coefficients Model			Random Slopes Model			
	Random Effect	*Std. Dev.*	*Variance*	*p-value*	*Std. Dev.*	*Variance*	*p-value*	***Add. Variance Explained***
Phoenix	INTRCPT1, u0	0.1587	0.0252	<0.001	0.1554	0.0242	<0.001	**4.1%**
	RETAIL slope, u1	0.1844	0.0340	<0.001	0.1828	0.0334	<0.001	**1.8%**
	MAN slope, u2	0.1982	0.0393	<0.001	0.1968	0.0387	<0.001	**1.4%**
	KNOW slope, u3	0.2449	0.0600	<0.001	0.2345	0.0550	<0.001	**8.3%**
	level-1, r	0.7109	0.5054		0.7109	0.5054		
Boston	INTRCPT1, u0	0.0834	0.0070	<0.001	0.0832	0.0069	<0.001	**0.4%**
	RETAIL slope, u1	0.1471	0.0216	<0.001	0.1186	0.0141	0.001	**35.0%**
	MAN slope, u2	0.0486	0.0024	>0.500				
	KNOW slope, u3	0.0946	0.0090	0.001	0.0834	0.0070	<0.001	**22.2%**
	level-1, r	0.5829	0.3398		0.5833	0.3402		

Note: all variables grand-mean centered

Table 5. Final model results for Phoenix and Boston.

	Phoenix			Boston		
Fixed Effect	*Coefficient*	*SE*	*Sig.*	*Coefficient*	*SE*	*Sig.*
For INTRCPT1, β0						
INTRCPT2, γ00	5.021	0.010	***	11.086	0.008	***
BLKNH	0.323	0.093	***			
TRANS	0.661	0.299	**	-0.290	0.106	***
DENSITY	-0.006	0.002	***			
AVG_SHAP	0.00002	0.00001	*			
B_AGE_HI	-0.175	0.070	**			
MIX				0.053	0.027	*
For RETAIL slope, β1						
INTRCPT2, γ10	0.565	0.016	***	0.431	0.018	***
TRANS				0.354	0.142	**
DENSITY				-0.0007	0.0002	***
B_AGE_HI				-0.200	0.091	**
MIX				-0.084	0.044	*
For KNOW slope, β2						
INTRCPT2, γ20	0.503	0.018	***	0.266	0.013	***
TRANS,	-1.391	0.481	***			
DENSITY	0.007	0.003	**			
B_AGE_HI	0.323	0.132	**			
For MAN slope, β3						
INTRCPT2, γ30	0.566	0.019	***			
TRANS	-0.730	0.431	*			
DENSITY	0.008	0.004	*			
B_AGE_HI	0.232	0.120	*			

p-values: *** ≤ .01, ** ≤ .05, * ≤ .1

Note: all variables grand-mean centered; only significant results shown

Table 6. Summary of model results.

Observation	Method	Model Result					
		Phoenix			*Boston*		
1. Neighborhood-level characteristics predict business performance	Intraclass correlation coefficient (ρ)	*Confirmed*; ρ = 5.3%			*Confirmed*; ρ = 3.0%		
2. Walkable BE features relate to higher business performance, controlling for industry effects	Random slopes model	*Confirmed* for TRANS (+) & B_AGE_HI (-)		*Denied* for DENSITY (-) & AVG_SHAP (+)	*Confirmed* for MIX (+)		*Denied* for TRANS (-)
3. Walkable BE features relate to higher business performance for specific industries	Random slopes model	*Industry*	*Confirmed* for	*Denied* for	*Industry*	*Confirmed* for	*Denied* for
		RET	–	–	RET	TRANS (+) & B_AGE_HI (-)	DENSITY (-) & MIX (-)
		KNOW	DENSITY (+)	TRANS (-) & B_AGE_HI (-)	KNOW	–	–
		MAN	DENSITY (+)	TRANS (-) & B_AGE_HI (-)	MAN	–	–

Appendix A. Descriptive statistics and Variance Inflation Factors (VIF).

Level	Variable Name	Phoenix							Boston						
		VIF	*Confd.*	*Final Model*	*N*	*Mean*	*Min.*	*Max.*	*VIF*	*Confd.*	*Final Model*	*N*	*Mean*	*Min.*	*Max.*
Level-1	LOGSALES	-			27185	5.07	-0.29	8.86				26513	11.13	2.91	17.45
	RETAIL	1.08		X	27185	0.17	0	1	1.05		X	26513	0.09	0	1
	MAN	1.07		X	27185	0.06	0	1	1.01			26513	0.02	0	1
	PROF_OFF	1.14		X	27185	0.19	0	1	1.19		X	26513	0.27	0	1
Level-2	MEDAGE	**5.06**			357	33.22	0	55.30	1.39	**DENSITY**		175	35.89	0	76.30
	WHTNH	**30.64**			357	0.48	0	0.95	**43.12**			175	0.48	0	1
	BLKNH	2.45		X	357	0.06	0	0.38	**22.74**			175	0.22	0	0.90
	ASNNH	1.99		X	357	0.03	0	0.36	**7.61**			175	0.08	0	0.70
	HISP	**11.90**			357	0.39	0	0.94	**8.45**			175	0.17	0	0.72
	BACH	**6.97**			357	0.25	0	0.73	**5.94**			175	0.43	0	1
	TRANS	1.74		X	357	0.04	0	0.27	2.97		X	175	0.32	0	0.73
	DENSITY	2.12		X	357	10.76	0.02	54.07	4.27		X	175	54.88	0.03	262.38
	AVG_SHAP	1.88		X	357	3773	1985	16588	3.96	**DENSITY**		175	1986	969	5035
	B_AGE_HI	1.66		X	357	0.37	0	0.98	1.67		X	175	0.41	0	1
	MIX	1.32	**TRANS**		357	0.03	0	1	2.43		X	175	0.10	0	1
	PEDB	1.80		X	357	0.03	0	0.30	**6.49**			175	0.16	0	0.66
	TRANSLAG	-							2.64		X	175	0.32	0.10	0.62
	POPEDLAG	-							**5.71**			175	52.14	5.94	183.94
	MEDALAG	**10.29**			357	33.44	22.68	47.85	-						
	WHITELAG	**22.04**			357	0.49	0.08	0.92	-						
	BACHLAG	**9.65**			357	0.25	0.04	0.61	-						